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CITY OF FEDERAL WAY

Shoreline Inventory and Characterization Report

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City of Federal Way

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1.0 INTRODUCTION

1.1 Background and Purpose

The purpose of this study is to conduct a baseline inventory and characterization of conditions relevant to the shoreline resources of the City of Federal Way (City), Washington. According to Substitute Senate Bill (SSB) 6012, passed by the 2003 Washington State Legislature, cities and counties are required to amend their local shoreline master programs (SMPs) consistent with the Shoreline Management Act (SMA), Revised Code of Washington (RCW) 90.58 and its implementing guidelines, Washington Administrative Code (WAC) 173-26. The City is updating its SMP with the assistance of a grant from the Washington Department of Ecology (Ecology) (Grant Agreement No. G0600119). A first step in the comprehensive update process is development of a shoreline inventory and characterization. The inventory and characterization documents current shoreline conditions and provides a basis for updating the City's SMP goals, policies, and regulations. This characterization will help the City identify existing conditions, evaluate existing functions and values of its shoreline resources, and explore opportunities for conservation and restoration of ecological functions. This study characterizes ecosystem-wide processes and how these processes relate to shoreline functions. Processes and functions are evaluated at two different scales: a watershed or landscape scale, and a shoreline reach scale. The purpose of the watershed or landscape scale characterization is to identify ecosystem processes that shape shoreline conditions and to determine which processes have been altered or impaired. The intent of the shoreline reach scale inventory and characterization is to: 1) identify how existing conditions in or near the shoreline have responded to process alterations; and 2) determine the effects of the alteration on shoreline ecological functions. These findings will help provide a framework for updates to the City's shoreline management policies and regulations, which will occur later this year.

This shoreline inventory and characterization report was prepared by ESA Adolfson (Adolfson) with technical assistance from EnviroVision Corporation, Coastal Geologic Services, and Shannon & Wilson, Inc.

1.2 Report Organization

The information in this report is divided into seven main sections. The introduction discusses the purpose of this report and describes the regulatory context for shoreline planning. The second section describes the methods, approach, and primary data sources used for this inventory and characterization. The third section provides an overview of ecosystem-wide processes and how they affect shoreline ecological functions in the City of Federal Way. The fourth section discusses physical features and biological conditions in or immediately adjacent to the Puget Sound shoreline in Federal Way. The fifth section addresses these conditions for the freshwater lakes in the City and its Potential Annexation Area (PAA). The sixth section describes opportunities for conservation and restoration of shoreline areas in the City. The seventh section identifies data gaps and provides recommendations for addressing those gaps. Finally, the last section (Section 8) provides the overall conclusions and summaries of the shoreline inventory and characterization report.

Appendix A of this report is a map folio that includes several figures that identify the City's approximate shoreline planning area and document various biological, land use, and physical elements at a variety of scales. Appendix B is the previous marine inventory report for Water Resource Inventory Area (WRIA) 9 prepared for Seattle Public Utilities (Anchor 2004). Appendix C is the prioritization of marine shorelines of WRIA 9 prepared by Anchor (2006).

1.3 Regulatory Overview

1.3.1 Shoreline Management Act and Shoreline Guidelines

Washington's Shoreline Management Act (SMA) was passed by the State Legislature in 1971 and adopted by the public in a referendum. The SMA was created in response to a growing concern among residents of the state that serious and permanent damage was being done to shorelines by unplanned and uncoordinated development. The goal of the SMA was "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines." While protecting shoreline resources by regulating development, the SMA is also intended to provide for appropriate shoreline use by encouraging land uses that enhance and conserve shoreline functions and values.

The primary responsibility for administering the SMA (Chapter 90.58 RCW) is assigned to local governments through the mechanism of local SMPs. The Washington Department of Ecology is responsible for reviewing and approving local master programs, approving some permit decisions under the SMA, and developing guidelines for the development and amendment of local master programs. The state guidelines (WAC 173-26) establish an overarching framework of goals and policies that are implemented through local master programs, which contain goals, policies, and use regulations for each city and county. Local SMPs are based on state guidelines but tailored to the specific conditions and needs of individual communities. Local SMPs are also meant to be a comprehensive vision of how the shoreline area will be managed over time.

1.3.2 Shoreline Jurisdiction

Under the SMA, the shoreline jurisdiction includes areas that are 200 feet landward of the ordinary high water mark (OHWM) of waters that have been designated as "shorelines of statewide significance" or "shorelines of the state." These designations were established in 1972 and are described in WAC 173-18. Generally, "shorelines of statewide significance" include portions of Puget Sound and other marine waterbodies, rivers west of the Cascade Range that have a mean annual flow of 1,000 cubic feet per second (cfs) or greater, rivers east of the Cascade Range that have a mean annual flow of 200 cfs or greater, and freshwater lakes with a surface area of 1,000 acres or more. "Shorelines of the state" are generally described as all marine shorelines and shorelines of all other streams or rivers having a mean annual flow of 20 cfs or greater and lakes with a surface area 20 acres or greater.

Under the SMA, the shoreline area to be regulated under the City's SMP must include all shorelines of statewide significance, shorelines of the state, and their adjacent shorelands, defined as the upland area within 200 feet of the OHWM, as well as any associated wetlands (RCW 90.58.030). "Associated wetlands" means those wetlands that are in proximity to and either influence or are influenced by tidal waters or a lake or stream subject to the SMA (WAC

173-22-030 (1)). These are typically identified as wetlands that physically extend into the shoreline jurisdiction, or wetlands that are functionally related to the shoreline jurisdiction through surface water connection and/or other factors. The specific language from the RCW describes the limits of "shorelands" as follows:

> *Those lands extending landward for two hundred feet in all directions as measured on a horizontal plane from the ordinary high water mark(OHWM); floodways and contiguous floodplain areas landward two hundred feet from such floodways; and all wetlands and river deltas associated with the streams, lakes and tidal waters that area subject to the provisions of this chapter.* (RCW 90.58.030(2)(f)).

Local jurisdictions can choose to regulate development under their SMPs for all areas within the 100-year floodplain or a smaller area as defined above (RCW 90.58.030(2)(f)(i)). The SMA shoreline jurisdiction discussed in this inventory includes both land and water defined as shorelines, shorelands, and "shorelines of the state."

The Puget Sound, as a marine waterbody, is designated a "shoreline of statewide significance" in the SMA (RCW 90.58.30(2)(e)(iii)) and given special consideration. As a shoreline of statewide significance, the Puget Sound must be recognized and protected as a statewide resource.

1.3.3 City of Federal Way Shoreline Master Program

The City has two main types of water bodies that are regulated under the SMA and the City's SMP (Figure 1). The City is bound on the west by the lower Puget Sound marine coastal shoreline, which is designated a "shoreline of statewide significance." There are also several freshwater lakes under SMA regulation within the City limits. These include Steel Lake, the northwestern shore of Lake Killarney, and North Lake.

The City of Federal Way in conjunction with the county and other local municipalities has identified an area largely to the east of the City and the Interstate 5 corridor for future annexation. This area is in the King County designated Urban Growth Area (UGA) and is referred to as the City's Potential Annexation Area (PAA). Lakes subject to SMA regulation located within the City's PAA include Star Lake, Lake Dolloff, Five Mile Lake, Lake Geneva, and the remaining portions of Lake Killarney. The freshwater lakes are all designated as "shorelines of the state." Lakes or portions thereof in the PAA (as well as the eastern shore of Lake Killarney) are currently regulated under the King County SMP.

State Master Program Guidelines (WAC 173-26-150 and 176-26-160) give local jurisdictions the option to plan for shorelines in designated Urban Growth Areas and PAAs. The Ecology grant for the City of Federal Way requires that the City plan for shorelines of the state, which lie within the PAA. However, regulated shorelines in the PAA would continue to be regulated under the provisions of the King County SMP until the City annexes those areas. King County is required to update its SMP for shorelines throughout unincorporated portions of the County, including designated UGAs, by the end of 2009.

There are no rivers or streams in Federal Way regulated under the SMA. However, the headwaters of Hylebos Creek lie within the City. Downstream portions of Hylebos Creek, where the East and West branches converge, are regulated shorelines of the state within the Cities of Milton, Fife and Tacoma.

At the time of incorporation in 1990, the City of Federal Way adopted the King County SMP. In 1998 and 1999, the City developed and adopted its own local SMP. Shoreline management goals and policies are contained in the land use element of the Federal Way Comprehensive Plan (FWCP, Section 2.8.5). Shoreline development regulations and permitting procedures are codified in Chapter 18, Article III, of the Federal Way City Code (FWCC §18-161 through §18-176).

Local SMPs establish a system to classify shoreline areas into specific "environment designations." The purpose of shoreline environment designations is to provide a uniform basis for applying policies and use regulations within distinctly different shoreline areas. In a regulatory context, shoreline environment designations function similarly to zoning overlay districts. That is, they do not change the underlying zoning or other applicable land use regulations, but provide an additional layer of policy and regulations that apply to land within the SMP jurisdiction. The shoreline environment designation or classification system should be based on the biological and physical character of the shoreline, the existing and planned land use patterns, and the goals and aspirations f the community for its shorelines. During development of its current SMP, the City evaluated the natural and built characteristics of its shoreline jurisdiction and developed four shoreline environment designations: Natural, Conservancy Residential, Rural, and Urban.

A variety of other regulatory programs, plans, and policies work in concert with the City's SMP to manage shoreline resources and regulate development near the shoreline. The City's Comprehensive Plan establishes the general land use pattern and vision of growth the City has adopted for areas both inside and outside the shoreline jurisdiction. Various sections of the City's municipal code are relevant to shoreline management, such as zoning and stormwater management. The City's development standards and use regulations for environmentally critical areas are particularly relevant to the City's SMP. Designated environmentally critical areas are found throughout the City's shoreline jurisdiction, including streams, wetlands, frequently flooded areas, aquifer recharge areas, geologic hazard areas, and fish and wildlife habitat conservation areas.

1.4 Shoreline Planning Areas

The approximate extent of shoreline jurisdiction within the City of Federal Way and in its PAA is shown on Figure 1, and referred to as the "shoreline planning area." In general, this extent represents:

- 200 feet landward from the mapped waterline edge (to approximate OHWM) of the Puget Sound coastal shoreline;
- Marine waters and beds of tidal and subtidal lands of Puget Sound within the City limits;

- 200 feet landward from the mapped waterline edge of seven freshwater lakes - Steel Lake, Lake Killarney, North Lake, Five Mile Lake, Star Lake, Lake Dolloff, and Lake Geneva;
- Water and bed of these same seven freshwater lakes;
- All special flood hazard areas currently mapped by FEMA that are associated with Puget Sound, streams discharging to Puget Sound, and the freshwater lakes; and
- All mapped wetlands that lie adjacent and contiguous to the areas above.

This approximate extent of shoreline jurisdiction should be considered useful for planning purposes only since its resolution is based on relatively coarse mapping. Site-specific delineation of floodplains, wetlands, and/or OHWM could result in modifications to the actual regulatory extent of shoreline areas.

For purposes of the shoreline inventory and characterization, the shoreline planning area was divided into reach units. The coastal Puget Sound shoreline was divided into three reaches while each lake is designated its own reach. The extent and general description of the individual shoreline reaches that comprise the City's shoreline planning area are summarized in Table 1. The rationale for delineating reach breaks is described in Section 2, Methods.

Table 1. City of Federal Way Shoreline Planning Area

Shoreline	Reach Number	Approximate Length (miles)	General Description
Coastal Puget Sound - East	1A	1.67	From the City limits boundary with Des Moines on Puget Sound, near 1st Avenue South, extending west to Dumas Bay
Coastal Puget Sound – Dumas Bay	1B	1.43	Dumas Bay
Coastal Puget Sound – West	1C	1.74	From Dumas Bay extending west to the City limits along the King/Pierce County line, including Dash Point State Park
Steel Lake	2	1.69	Inside the City limits, west of I-5.
Star Lake	3	1.33	Inside the northeast portion of the City's PAA, near the boundary with City of Kent
Lake Dolloff	4	1.81	Inside the northeast portion of the City's PAA, near I-5 and Military Road.
Lake Geneva	5	1.12	In the southeast portion of the City's PAA, southeast of SR 18.
North Lake	6	2.16	Inside the City limits, between I-5, SR 18, and Military Road
Lake Killarney	7	2.12	Partially in the City limits, partially in the southeast portion of the City's PAA, east of I-5 and SR 18.
Five Mile Lake	8	1.87	In the southeast portion of the City's PAA, near Military Road.
Total		**16.93**	Approximately 4.84 miles of Puget Sound shoreline and approximately 12.09 miles of lake shoreline.

2.0 METHODS

The following data sources and methodologies were used to complete this inventory and characterization report.

2.1 Data Sources

A number of City of Federal Way, King County, state agency, and federal agency data sources and technical reports were reviewed to compile this inventory and characterization, including but not limited to the following:

- City of Federal Way Comprehensive Plan (2002);
- City of Federal Way Surface Water Facilities Plan (1994);
- City of Federal Way Potential Annexation Area Inventory (2002);
- Washington State ShoreZone Inventory (2001);
- Coastal Zone Atlas of Washington, King County (1979);
- The Catalog of Washington Streams and Salmon Utilization, Volume 1, Puget Sound Region (1975);
- Washington State Department of Fish and Wildlife Priority Habitats and Species, Washington Lakes and Rivers Information System Database and Marine Resource Species information (2006);
- Marine Shoreline Inventory Report - WRIA 9. Prepared for Seattle Public Utilities and WRIA 9. (Anchor Environmental, 2004 – Appendix B); and
- Inventory and Assessment of Current and Historic Beach Feeding Sources/Erosion and Accretion Areas for the Marine Shorelines of Water Resource Inventory Areas 8 & 9., Prepared by Coastal Geologic Services for King County Department of Natural Resources and Parks (Johannessen et al., 2005).
- Final Report, Prioritization of Marine Shorelines of WRIA 9 for Juvenile Salmonid Habitat Protection and Restoration. Prepared for WRIA 9 Technical Group. (Anchor Environmental, 2006 – Appendix C).
- Steel Lake Integrated Aquatic Vegetation Management Plan (updated 2004).
- North Lake Integrated Aquatic Vegetation Management Plans (2004).
- King County Volunteer Lake Monitoring Results for the Water Year 2003 – 2004.
- King County Lake Water Quality – A Trend Report on King County Small Lakes (2001).

A number of sources were also reviewed to characterize overall watershed and Puget Sound nearshore conditions and to assess the ecological function of the Federal Way shorelines in an

ecosystem-wide context. Watershed- and Puget Sound-level condition sources reviewed for this report include:

- Reconnaissance Assessment of the State of the Nearshore Report: Including Vashon and Maury Islands (WRIAs 8 and 9) (2001);
- Occurrence and Quality of Ground Water in Southwestern King County, Washington (1995);
- Geology and Ground-Water Resources of Southwestern King County, Washington (1969);
- Soil Survey of King County Area, Washington (1979);
- Washington Trout Water Type Survey Results, South King County (2004);
- Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island) (2000); and
- Coastal Bluffs and Sea Cliffs on Puget Sound, Washington (2004).

Historic and current mapping and aerial photographs of the study area were consulted, and staff biologists, geologists, and planners conducted a reconnaissance field survey of the City's shoreline jurisdiction at existing public access locations. Sources of information on cultural and historic resources included the Federal Way Historical Society website and consultation with the King County Historic Preservation Program and the Washington Office of Archaeology and Historic Preservation.

2.2 Approach to Characterizing Ecosystem-Wide Processes and Shoreline Functions

SMA guidelines require local governments to evaluate ecosystem-wide processes during SMP updates. Ecosystem-wide processes that create, maintain, or affect the City's shoreline resources were characterized using an adapted version of the five-step approach to understanding and analyzing watershed processes described in *Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes* (Stanley et al., 2005). This approach defines watershed processes as the delivery, movement, and loss of water, sediment, nutrients, toxins, pathogens, and large woody debris. Detailed information about each of these five watershed process components is either not available or not fully relevant to the City's marine and freshwater shorelines. For this report, discussion of ecosystem processes focuses on climate, topography, geology and soils, surface and groundwater, coastal processes, and water quality. Process components, as identified by Stanley et al. 2005, that are not directly called out within this report, are discussed under other headings (i.e., available information about toxins, pathogens, and nutrients is discussed within Section 3.1.6, Water Quality) and/or identified in Chapter 7 as a data gap.

Processes are qualitatively described using available reports and spatial information related to topography, geology, soils, land cover, and other themes. This approach is most appropriate at the watershed scale. Conditions and processes at the watershed scale inform local planning by providing a broader understanding of processes that influence shoreline conditions and functions.

Natural processes, and alterations to those processes, are described at a variety of geographic scales based on existing reports and readily available mapping information. No new quantitative analyses were performed to develop the summaries and characterization included in this document.

For marine shorelines, processes are described in the context of coastal processes in Puget Sound generally, and how those processes are affected by conditions in the Federal Way shoreline. For upland areas, processes and conditions in areas outside of the shoreline jurisdiction, but which may influence shoreline conditions and functions, are described. Surface water drainage basins delineated by King County Surface Water Management were used to delineate areas that contribute flow to regulated waterbodies (i.e., Puget Sound and freshwater lakes) in the City and its PAA.

2.3 Approach to Inventory and Characterization of Shorelines at the Reach Scale

The inventory of Puget Sound and lakes at the shoreline reach scale is intended to characterize conditions in and adjacent to the regulated waterbody. The shoreline planning area roughly approximates the regulatory limits of the City's SMP, and lakes within the City's PAA, as described in section 1.4. GIS data were used to quantify certain conditions in this area (e.g., spatial extent of zoning or land uses). Aerial photography, review of existing reports, and brief field reconnaissance were used to qualitatively describe conditions in the shoreline.

Reach boundaries are shown on Figure 1. Puget Sound was inventoried in three reaches, described above. Reaches were delineated based on significant changes in the physical and biological resource composition of the Puget Sound shoreline in the City. Reach 1A, Puget Sound East, is characterized by variable topography (i.e., bluffs transitioning into lower gradient topography) and variable densities of development. Reach 1B, Dumas Bay, is distinct as a marine bay and estuarine delta with several freshwater stream inputs. Reach 1C, Puget Sound West, is characterized by variable topography, low-density development, and significant recreational open space at Dash Point State Park. Each freshwater lake was inventoried as one reach, due to the size and relatively consistent level of development of the lakes. Although distinct variations in level of development are seen along the shorelines of each freshwater lakes (especially between the east and west shorelines of North Lake), the relatively small total size of each shoreline allowed them to be best inventoried and described within this report as one reach each.

3.0 SHORELINE FUNCTIONS

The ecosystem-wide processes that form and maintain Federal Way's coastal/nearshore shorelines and freshwater lakes are focused on hydrology (i.e., the quantity and timing of surface flow and groundwater flow characteristics). These processes occur at a landscape or watershed scale and serve to form, maintain, or influence shoreline ecological functions. Examples of shoreline functions include habitat structure, nutrient filtering, and vegetation (which provides temperature control and organic inputs).

Changes in land use patterns and development across the landscape, not solely at the water's edge, may change these processes and alter shoreline functions. Geographic areas that are important in maintaining these processes are discussed at the watershed scale generally, and more specifically in the vicinity of Federal Way and its PAA. This section discusses the watershed context of Federal Way and its PAA and the key processes affecting shoreline functions for both the coastal Puget Sound and the freshwater lake shorelines.

3.1 Watershed Context

Water flow drives many ecological processes; therefore a useful characterization study area is the watershed. Surface and groundwater flow in the watershed is controlled by climate, topography, vegetation, soils, and geologic conditions. In Washington State, watersheds at a large scale are organized into Water Resource Inventory Areas (WRIAs). The City of Federal Way is located within the Duwamish-Green River WRIA 9 and the Puyallup-White River WRIA 10 (Figure 2). An inventory of Federal Way's marine or coastal shoreline was conducted in January of 2004 as part of a report prepared for Seattle Public Utilities and WRIA 9 (Johannessen et al., 2005). This 2004/2005 inventory describes the coastal process in action along Puget Sound within the City. The freshwater shoreline lakes in the City are located at the headwaters of several drainage basins flowing to the two main watersheds.

The Duwamish-Green River (WRIA 9) watershed encompasses lands within the City and PAA that drain to coastal areas, Mill Creek and the lower Green River, including Mullen Slough. The Mill Creek Sub-basin drains the PAA area to the east of the City, including the area around Lake Dolloff (Reach 4) and Lake Geneva (Reach 5). The sub-basin stretches east and north of the City, eventually entering the Duwamish-Green Basin to the north of Auburn. The Lower Green River Basin drains the northwest corner of the City and the PAA to the northwest of the City, including the area around Star Lake (Reach 3). Water flow from this area of the City and PAA enters into Mullen Slough prior to draining to the Green River. The Lower Puget Sound Basin, including the area around Steel Lake (Reach 2) and the nearshore areas of Puget Sound are also within the WRIA 9 area.

The White River Basin (WRIA 10) drains the southwest areas of the City and the PAA, including the area around Five Mile Lake (Reach 8). The White River Basin joins with the Puyallup River Basin before entering Puget Sound at Commencement Bay. A large portion of the City and PAA lies within the Hylebos Creek Basin, including North Lake (Reach 6) and Lake Killarney (Reach 7) to the east. Hylebos Creek flows to the south beyond the City limits of Federal Way until the creek enters the Hylebos Waterway, a working seaport waterway in the City of Tacoma at Commencement Bay.

3.1.1 Climate

Federal Way is located in the greater Puget Lowlands of western Washington. This area, surrounding Puget Sound, has a maritime climate with cool winters, dry summers, and a distinct rainy season through fall and spring. The Federal Way area has recorded average January low temperatures of approximately 35° F and average July high temperatures of approximately 76 °F. Precipitation in the Puget Lowlands varies considerably because of the effects of mountains. The Federal Way area receives between 35 and 40 inches of rain per year on average, with approximately 75 percent of the precipitation falling between October and March (Woodward et al., 1995). Winds are generally from the southwest during the rainy season and from the northwest during the dry summer months.

3.1.2 Topography

Federal Way is located on a broad northerly-trending upland area (the Des Moines Plain) located between the Duwamish Valley and Puget Sound. The upland plateau largely lies between 200 to 400 feet above sea level. The area is bounded to the west by steep coastal bluffs and to the south and east by steep valley walls that lead down to the relatively flat, broad valley floors of the Puyallup and Duwamish Rivers (Figure 3).

Topography on the surface of the plateau is characterized by elongate, north-trending hills with relatively low relief in the range of 40 to 100 feet. The surface has local closed depressions occupied by lakes and poorly drained areas occupied by wetlands and peat bogs. Streams draining the watershed are relatively short and flow directly to Puget Sound or to the adjacent river valleys. Some of these streams have incised deep ravines into the coastal bluffs and valley walls.

3.1.3 Geology and Soils

The geology of the Federal Way vicinity is summarized by Waldron (1961) and Booth and others (2004 and in review). The geology along the marine shoreline is also documented in the Coastal Zone Atlas of King County (Washington State Department of Ecology [Ecology], 1979). Surficial geologic units are shown in Figure 4; soils classes are shown in Figure 5.

The upland plain at Federal Way is underlain by a sequence of glacial and nonglacial deposits that overlie Tertiary bedrock. The depth to bedrock in the vicinity of the Federal Way is approximately 1,000 to 1,500 feet (Jones, 1996). The area has been glaciated six or more times in the past 2 million years. Each glacial advance likely left a sequence of deposits that consisted of fine-grained lacustrine (lake) deposits, outwash sand and gravel, and till. Many of these deposits have been partially to completely eroded by subsequent glaciations or erosion during interglacial periods. The many lakes in the Federal Way area are formed within these glacially derived deposits.

The most recent incursion of glacial ice into the central portion of the Lowland is called the Vashon Stade of the Fraser glaciation, which receded from the area about 13,500 years ago. That glaciation is responsible for the majority of deposits that make up the surface of the upland plain. North-trending elongate hills, or drumlins, that form the surface of the upland plain were shaped by the moving ice sheet.

The steep-walled troughs that define the Duwamish and Puyallup Valley to the east and south of Federal Way were probably constructed as glacial ice or subglacial streams cut into deposits of previous glacial advances (Mullineaux, 1974; Booth, 1994). Following recession of the ice sheet, the troughs existed as historic embayments of Puget Sound. The troughs were filled principally by estuarine deposits, lahars and lahar derived sediment from Mount Rainier, and alluvium of the White and Green Rivers (Dragovich and others, 1994). Glacial and non-glacial deposits that predate the Vashon Stade are exposed in the steep walls of the troughs.

Steep coastal bluffs that define the western City limits of Federal Way were probably formed by coastal erosion following retreat of the ice sheet and regional drop in relative sea level (Shipman, 2004). Wave erosion at the base of the coastal bluffs, along with landsliding and mass wasting, have caused episodic but continual retreat of the shoreline. Landslide and mass-wasting deposits are exposed along these cliffs, along with older glacial and non-glacial sediments.

Most soils exposed at the ground surface within the study area are glacial deposits left during the most recent ice-sheet advance (Waldron, 1961; Booth and others, 2004). Lodgment till (associated with the Alderwood soil series; AgC, AgB, AgD, AkF, AmB, and AmC) mantles much of the upland area in the vicinity of Federal Way (Figure 4). The till is a poorly sorted mixture of gravel, sand, silt, and clay deposited at the base of a glacier. Till is typically very dense due to compaction by the overriding ice. Such deposits have very low permeability and often restrict the downward flow of groundwater.

Recessional outwash and recessional lacustrine deposits overlie the till in places on the upland plain. These sediments were deposited in topographic lows in the till surface where meltwater streams drained from the receding glacier, such as along the headwater areas of Mill Creek (Figure 4). The recessional outwash deposits typically consist of well-sorted sand and gravel. Recessional lacustrine deposits generally comprise silt and clay. Peat deposits are found on the surface of the plain on top of poorly drained lacustrine deposits or on top of outwash deposits that are underlain by till at shallow depths. The peat deposits are commonly associated with larger wetland areas within the watershed (Figures 4 and 5).

Underlying the till are thick deposits of sand and gravel separated by finer grained layers of clay and silt or tight, well-graded soils, such as till from previous glaciations. These layers comprise several aquifers and aquitards within the subsurface and control subsurface water movement to the shorelines and adjacent valleys.

3.1.4 Surface and Groundwater

There are five major stream systems in Federal Way, including West Hylebos Creek, Cold Creek, Joe's Creek, Lakota Creek and Redondo Creek (Figure 6). The City's surface water bodies also include several lakes, only two of which (Steel and North Lakes) are considered shorelines of the state; these are: Steel, Panther, Easter, Mirror, Lorene, Jeanne, and North. Lakes in Federal Way's PAA include Star, Dolloff, Geneva, Killarney and Five Mile. In addition, many unique, rare and useful wetlands and bogs are spread throughout the city, including West Hylebos Wetlands State Park and Fisher's bog.

Federal Way lies within the South King County Groundwater Management Area. Information concerning groundwater recharge, monitoring, contamination, and management specific to the Federal Way area is readily available on the King County Groundwater Management website (http://dnr.metrokc.gov/wlr/wq/ groundwater-data.htm). Groundwater and hydrology of the watershed is described by Luzier (1969) and Woodward et al. (1995). Additional analysis and groundwater protection planning are being conducted under King County's Groundwater Management Program.

The Des Moines Plain (described in Section 3.1.2) surface has several small lakes and numerous streams that flow short distances from the upland area to the shoreline and adjacent valleys (depicted for the Federal Way area within Figure 6). Precipitation falling within the watershed is conveyed directly to lakes and streams by surface runoff or travels in the subsurface as groundwater flow. Water from precipitation generally soaks into the ground, but during heavy rainfall the ground quickly becomes saturated, inhibiting further infiltration. Water that is unable to infiltrate travels down slope across the ground surface as stormwater runoff. Surface runoff may erode soil, which is conveyed to streams and eventually to the shoreline of Puget Sound.

Impermeable surfaces such as pavement, rooftops, or compacted ground increase stormwater runoff. Conversely, vegetation promotes infiltration by intercepting rainfall, effectively spreading precipitation events over longer periods of time and reducing peak flows and associated sediment transport. Vegetation also reduces erosion by holding soil in place and reducing splash erosion.

Poorly drained areas of the upland plateau are the sites of former or existing wetlands. Wetlands regulate the flow of water within a watershed by storing water during precipitation events, slowing the conveyance of water from the upland to the shoreline, and increasing infiltration. Development has reduced the number and area of wetlands in the upland plateau, causing higher volumes and peak rates of stormwater runoff.

Water that infiltrates into the ground generally flows downward until impeded by less permeable soils and then flows laterally to a body of water or to a slope face where it may emerge as springs or seeps on the hillside. A portion of the groundwater, however, will percolate downward through lower-permeability soils to underlying more permeable soils or aquifers. Because of the complex stratigraphy of soils in the Puget Lowland, several aquifers exist within the subsurface. For the uppermost aquifer beneath the till, groundwater flow is radially outward from a groundwater high that lies beneath Star Lake (Woodward et al., 1995). Several deeper aquifers exist within outwash deposits in older glacial drift. Groundwater highs for the uppermost of these aquifers are situated to the south of Star Lake and just south of Dumas Bay.

3.1.5 General Coastal Processes

The shores of Federal Way encompass 4.8 linear miles from the intersection of Redondo Beach Drive South and 1st Avenue in Des Moines southwest to the King-Pierce County line (DNR 2001). The major factors influencing the beaches of Federal Way include the local geology, fluvial systems, and variable degrees of wave exposure and development. The beaches of Federal Way are generally of two different characters, eroding bluffs or estuarine shores, with varying degrees of development and related shore modifications (Figure 7).

The coastal zone is a dynamic environment, and human actions can easily alter the natural system. Therefore, it is important for communities to understand potential impacts of land use. General coastal processes are well summarized in the *Coast of Puget Sound* by Downing (1983) and by Shipman (2004). Steep, gradually receding bluffs back much of the shoreline in Federal Way (Downing, 1983; Shipman, 2004). Over time, the bluffs erode and recede landward, providing sediment to the shore. Prior to construction of bulkheads and other structures that were intended to protect property from wave and tidal action, intermittent landslides occurred along bluff shores, although natural bluff recession rates were generally quite slow in most of Puget Sound. Sediment that accumulates at the base of the bluff helps to protect the bluff from further erosion and reduces the recession rate. Sediment from eroded bluffs may enter the intertidal zone within the nearshore, where it is subject to wave transport and water currents (Figure 7).

Prevailing winds and waves cause littoral drift, which is the movement of loose sediment along the shore, primarily within the intertidal zone. Sediment that is sufficiently small, typically sand, is suspended for short durations by wave action and is transported along the shore parallel to the beach. Gravel is transported by rolling (saltation) as a result of storm waves, and plays an important role in beach stability. The direction of drift transport is generally in the direction of prevailing winds, which may differ in the summer and winter. The predominant, or net-shore drift direction is the most important consideration for coastal processes (Figure 7). Where natural net-shore drift is blocked, beach processes are altered. Transported sand and gravel accumulates on the updrift side of shore obstructions (the side opposite the net-shore drift direction) and is depleted on the downdrift side of obstructions by blocking the transport of drift material. Such obstructions include human-built structures such as bulkheads, breakwaters, groins, docks, and boat ramps (depicted along the Federal Way marine shoreline in Figure 11). In areas where the beach is depleted, erosion accelerates. Shoreline armoring using bulkheads and other hardened structures eliminates the transport of sediment to the beach from natural upland sources. The elimination of sediment supplied to the shore also results in an increase in erosion processes along the beach.

Owners of property adjacent to the shore commonly construct rock or concrete bulkheads to protect the bank or bluff from erosion. Such measures can increase beach depletion as wave energy is reflected rather than absorbed. The shoreline processes and conditions along the Federal Way coastline are summarized in the *Net-shore Drift of King County* (Chrzastowski, 1982), which updated the coastal drift section of the *Coastal Zone Atlas of King County* (Ecology, 1979). These processes and conditions have been re-evaluated by Johannessen and others (personal communications) in work completed in 2005 for WRIA 9.

3.1.6 Water Quality

Section 303(d) of the Federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the State for which beneficial uses of the water, such as drinking, recreation, aquatic habitat, and industrial use, are impaired by pollutants. The Washington Department of Ecology maintains a 303(d) list of waterbodies where tested pollutants exceed thresholds established by the state surface water quality standards (WAC 173-201A). Lakes and streams that do not appear on the 303(d) list may fall short of that pollutant threshold, but may not be free of pollutants. In addition, not all streams or all stream reaches are tested as part of this process. Therefore, absence from the 303(d) list does not necessarily indicate that the

waterbody is not impaired. . Washington State's 2004 303(d) list is the most recent to be submitted to approved by the federal Environmental Protection Agency (EPA). The 1998, 303(d) list was the previous list approved by the EPA before submittal and approval of the 2004, 303(d) list.

Table 2 shows the waterbodies within the City and its PAA that were listed in both the 2004 and 1998 approved 303(d) lists, as well as the water quality parameters that exceeded standards for the class of water tested. Joe's Creek is included on Washington State's 2004, and 1998, 303(d) lists.

Table 2. 303(d) Water Quality Exceedances in Federal Way and its PAA

Waterbody Name	Exceeded Water Quality Parameter	Listed Year		Medium	Within City/PAA
		1998	2004		
Puget Sound Central	Dioxins		✓	Water	✓
	Furans		✓	Water	✓
	Total PCBs		✓	Water	✓
Joe's Creek	Fecal Coliform	✓	✓	Water	✓
Hylebos Creek	Fecal Coliform	✓		Water	✓

Source: Washington State Department of Ecology, 2005

It should be noted that several lakes (Steel, Star, Dolloff, Geneva, Killarney and Five Mile) are listed erroneously on the 2004, 303(d) list. A reassessment of the data in January 2006 revealed that only two data points were submitted, meaning that they should be category 2 waters (due to lack of data). Since EPA had approved the list before Ecology noted the error, the listings could not be withdrawn.

The City of Federal Way monitors the quality of streams within the city limits. Surface Water Management maintains and operates water quality instruments throughout the city that continuously detect and record pollutant levels of concern. In addition, biological monitoring is performed annually in selected streams to help gauge the condition of the aquatic habitat, water quality, and overall ecosystem productivity. The City monitors streams within the city limits in order to identify water quality issues citywide and address water quality problems that may ultimately affect shorelines of the state.

3.2 Biological Resources

Biological components of the watershed are important factors in maintaining ecosystem-wide processes along with hydrologic and geologic components. The presence of vegetation serves to intercept rainfall and increase infiltration of surface water runoff. Trees and native plants provide habitat for fish and wildlife and contribute large woody debris as habitat components in the shoreline. Wetlands also provide functions in a watershed context to protect the ecosystem-wide processes that protect shoreline functions.

3.2.1 Vegetation

Historically, vegetation within the watershed was coniferous forest, deciduous riparian forest and wetland or other native habitat types (Johnson and O'Neil, 2001). Vegetation existing today within the watershed is largely a function of the type and degree of residential and commercial development within the Federal Way area. Little natural vegetation remains within the urbanized City as it has developed in commercial, industrial, and low- to high-density residential land uses. Native vegetation is restricted to undeveloped areas, and includes land along existing wetlands and streams. In addition, the areas preserving the greatest amount of native vegetation are the steeper slopes between the upland and lowland areas, and open space areas, such as parks.

Native vegetation in undeveloped or less developed areas of the City comprises trees, such as Douglas fir, western red cedar, western hemlock, big-leaf maple, and red alder. Western red cedar, once dominant in wetter areas, is less common. Common upland understory plants include salal, ferns, Indian plum, Oregon grape, elderberry, oceanspray, salmonberry, and snowberry. Non-native plant species, such as Himalayan blackberry, cut-leaf blackberry, Scot's broom and reed canarygrass, are also present within the forested habitats (Johnson and O'Neill, 2001). Vegetation present in developed areas may include native plant species, but ornamentals or landscaping varieties are more prevalent. A reduction in native vegetation and primarily forested cover occurs as land is developed in urban uses.

3.2.2 Wetlands

Wetlands are an important component of a healthy watershed, providing functions such as floodwater storage, stormwater detention, water quality improvement, shoreline protection and habitat for fish and wildlife. In Federal Way, a wetland inventory was completed in 1999 that identified a total of 232 wetlands, 170 of which were within the City limits and 55 of which were in the unincorporated PAA (Figure 6). Of all wetlands surveyed, more than half were less than 1 acre in size and more than 80 percent were less than 5 acres in size. Wetlands were rated using the City's three-tiered rating system that incorporates wildlife and plant species identified, ecological functions and other wetland characteristics (FWMC 18-28, Sheldon and Associates, 1999). The higher value Category I wetlands make up large portions of the total wetland acreage both within the City (50 percent) and the PAA (75 percent). Wetland inventoried in the City and its PAA are largely associated with existing lakes and streams.

Within the City, wetlands were identified most frequently in association with West Hylebos Creek, Lakota Creek, and Joe's Creek. Within the PAA, wetlands were identified most frequently in association with Mill Creek and East Hylebos Creek. Several important wetlands and bogs occur throughout the city, including West Hylebos Wetlands State Park and Fisher's bog.

Wetlands in the City are regulated through Article XIV. Critical Areas. Wetlands are provided standard buffers and other protection measures in the critical areas ordinance. Standard buffers in the ordinance range from 25 feet to 200 feet. Critical areas protections for wetlands are designed to protect the functions and values of these areas.

3.3 Major Land Uses and Shoreline Uses

Historically, land use within the Federal Way area was predominantly timber-oriented. The U.S. Geological Survey created a Land Classification map of the Federal Way area in 1897. Within 0.5 to 1.5 miles of the marine shoreline, forests had been harvested for timber. Further inland from the marine shoreline, the majority of lands, including those surrounding the freshwater lake shoreline areas, were classified as "uncut merchantable forests." Throughout the City area the map shows small, interspersed areas of clearing and human development both along the marine shoreline and inland areas. (USGS, 1897)

By 1940, the development pattern in Federal Way was predominantly single-family homes located around lakes and along major roads (Figure 8). Vegetation had grown in some areas near the Puget Sound shoreline that had been previously harvested for timber. More significant development in the vicinity has occurred since 1940, with subdivision development throughout the City and commercial development along and between the SR 99 and Interstate-5 corridors (Figure 8).

Today, single-family residential development is the dominant land use, occupying approximately 42 percent of the land area in the City of Federal Way. Multi-family development occupies 11 percent of the total land area. Commercial developments (including office, retail, and industrial) occupy approximately 12 percent of the City's land area and are located primarily in the downtown area, and along major transportation corridors including Pacific Highway South and Interstate 5. One percent of the land area is made up of religious services. Parks and public beaches occupy 6 percent of the City's land area. Vacant lands occupy approximately 12 percent of the City (City of Federal Way, 2002).

3.4 Key Processes Related to Shoreline Functions

Ecosystem-wide processes that create, maintain, or affect the City's shoreline resources were characterized using an adapted version of the five-step approach to understanding and analyzing watershed processes developed by Ecology (Stanley et al., 2005). This approach defines watershed processes as the delivery, movement, and loss of water, sediment, nutrients, toxins, pathogens, and large woody debris.

The key processes affecting shorelines in Federal Way and the factors and mechanisms that control them are discussed in this section.

3.4.1 Processes Affecting Marine Coastal Shorelines

Federal Way beaches represent a commonly occurring beach character found in Puget Sound, having two distinct foreshore components: a high-tide beach and a low-tide terrace (Johannessen 1993). The high-tide beach consists of a relatively steep beachface with coarse sediment and an abrupt break in slope at its waterward extent. Sand in a mixed sand and gravel beach is typically winnowed from the high-tide beach by waves (Chu 1985) and deposited on the low-tide terrace. Extending seaward from the break in slope, the low-tide terrace typically consists of a gently sloping accumulation of poorly sorted fine-grained sediment (Komar 1976, Keuler 1979, Johannessen 1993). Lag deposits derived from bluff recession are also found in the low-tide

terrace. These deposits are typically comprised of larger materials, ranging from cobbles to boulders.

3.4.1.1 Beach Composition and Sediment Sources

Puget Sound beach composition is dependent upon three main influences: 1) wave energy, 2) sediment sources, and 3) relative position of the beach within a littoral cell. Wave energy is controlled by fetch; the open water over which winds blow without any interference from land. Within the Federal Way study area fetch is limited to 28 miles from the north (Adelaide to Indianola on the Kitsap Peninsula), and 5.5 miles to the northwest (Dash Point State Park to inner shores of Quartermaster Harbor). Segment exposure was classified by DNR's Shorezone inventory as "semi-protected" (DNR 2001). Eastern Federal Way marine shores have greater fetch than western shores that are protected by Vashon and Maury Islands to the north. The northern orientation of the shore precludes the region's predominant and prevailing southerly winds from exerting high wave energy on the shore.

Wind-generated waves gradually erode beaches and the toe of coastal bluffs, usually leading to landslides (Hampton and others 2004). These coastal bluffs are the primary source of sediment for most Puget Sound beaches, including the Federal Way study area (Keuler 1988, Downing 1983). Currently, 37 percent of the Federal Way's marine shores are comprised of eroding coastal bluffs (feeder bluffs; Johannessen et al., 2005).

Bluff composition and wave energy influence the composition of beach sediment. Waves sort coarse and fine sediment and large waves can transport cobbles that small waves cannot. This results in relatively fine-grained beaches where wave energy is lowest, as these waves cannot transport coarse gravel. Additionally beaches supplied by the erosion of coarse gravel bluffs will differ in composition from those fed by the erosion of sandy sediment. The exposed strata of the eroding bluffs in the northeastern portion of the study area are of a different character than those of the southwestern shores, resulting in spatial variability in beach materials. Northeastern beaches are typically made up of coarse material, typically comprised of coarse sands with moderate pebble, due to the poorly sorted, coarse stratum that makes up the bluffs (Qmw; WA DNR 2001) (Figure 4). The bluffs of the southwestern portion of the study area are composed of Vashon advance outwash deposits, which are predominantly composed of medium to fine-grained sand. As a result, beach material in the southwestern portion of the study area is finer grained and considerably sandier than the northeastern beaches of Federal Way (DNR 2001).

In addition to the previously mentioned influences (wave energy and sediment sources), tidal range also affects beaches over time. Rosen (1977) demonstrated that the coastal erosion rate increases with decreasing tidal range. This is due to the focusing of wave energy at a narrow vertical band with a small tidal range in comparison to the dissipation of wave energy over a large vertical band with a greater tidal range. The mean tidal range in the study area is roughly 10.5 to 11.9 feet or meso-tidal (2 – to 4 m range). This tidal range is lower than southern Puget Sound, which means that erosion will be primarily focused within the 10.5 to 11.9 feet of the beach profile exposed to tidal waters (excluding storm conditions). However, the majority of coastal erosion in the region occurs when high wind events coincide with high tides and act directly on the backshore and bluffs (Downing 1983).

Furthermore, periods of prolonged precipitation, in which coastal bluff soils become saturated, can provide additional beach sediment sources. It is during these periods, typically during winter, that the majority of coastal landsliding occurs (Tubbs 1974, Gerstel et al. 1997, Shipman 2004). This process is described in greater detail in Section 3.4.1.3.

3.4.1.2 Net Shore-drift

Wind-generated waves typically approach the shore at an angle, creating beach drift and longshore currents that result in sediment transport through a process called littoral drift. Net shore-drift refers to the long-term, net result of littoral drift. Net shore-drift cells represent a sediment transport sector from sediment source to sediment sink (deposition area) along a portion of coast. Each drift cell acts as a system consisting of three components: 1) a sediment source and origin of a drift cell (typically an eroding bluff area); 2) a transport zone where materials are moved alongshore by wave action with minimal sediment input; and 3) an area of deposition that acts as the drift cell terminus. Deposition of sediment occurs where wave energy is no longer sufficient to transport the sediment in the drift cell. Drift cells in the Puget Sound region usually range in length from 5 or more miles to just hundreds of feet.

The Federal Way study area contains one entire drift cell and two partial drift cells. The general patterns of net shore-drift will be briefly described with more detailed descriptions of sediment sources and depositional areas presented in the reach scale inventory. The northeastern portion of the study area falls within drift cell KI-9-2 (also referred to as KI-10-1), which exhibits southwestward drift. The drift cell originates approximately 2.4 miles northeast of the City boundary (approximately 1,050 feet north of Saltwater State Park). The drift cell terminates at a convergence with cell KI-10-2 in the southwest corner of Dumas Bay. Cell KI-10-2 originates east of a divergent zone at the southwestern headland that marks the western entrance to Dumas Bay. Divergent zones are the areas between drift cells where the net shore-drift direction changes. Cell KI-10-2 measures only 864 feet and exhibits southward drift. The western shore of the City, west of the divergence zone located west of Dumas Bay, marks the origin of cell KI-10-3 (also referred to as cell PI-1-1). This cell exhibits southwestward drift and terminates outside the study area, at the cuspate foreland at Dash Point.

3.4.1.3 Coastal Bluff Landslides

Coastal landslides typically occur during periods of high precipitation on bluffs with a combination of characteristics making the bluff more vulnerable to slope failure (Tubbs 1974, Gerstel et al. 1997). These characteristics include the underlying geology of a bluff or bank, its level of exposure (fetch), and the local hydrology (groundwater and surface water). As a result the exposed high-gradient bluffs and banks of the eastern and western portion of Federal Way are more susceptible to coastal landslides, relative to the central study area shore.

Landslides are more likely to occur in areas where there is a history of landslides or where the lower bluff stratum is comprised of a consolidated impermeable layer (such as dense silt or clay) that is overlain by an unconsolidated permeable layer (typically sands; Gerstel et al. 1997). As water seeps through the permeable layer and collects above the impermeable layer, a zone of weakness or “slip-plane” is created. This stratigraphic sequence is a common setting for mass

wasting (landslides) in central Puget Sound. Recent mapping (Johannessen et al. 2005) documented recent landslides across 18 percent of the Federal Way study area.

Undercutting of the toe of the bluff, from wave energy during storm events, is the long-term "driver" of bluff recession (Shipman 2004, Keuler 1988). Bluffs that are exposed to greater fetch are subject to higher wave energy during storms, resulting in greater toe erosion and bluff undercutting, thus more frequent landslides (Shipman 2004). Recent bluff toe erosion was documented along 28.1 percent of the Federal Way shores (Johannessen et al., 2005). Bulkheads reduce wave attack to bluff toes but can accelerate erosion of the beach (see *Shore Modifications* section, below).

Storms that coincide with elevated water levels, such as a storm surge or extraordinary high-high tide, often initiate landslides in the Puget Sound region (Johannessen and Chase 2003). The wave attack caused by a storm that occurs in conjunction with heightened water level can produce dramatic toe erosion, which then undermines and destabilizes a larger portion of the bluff that may not fail (slide) until subsequent wet-weather months.

Two springs were mapped along the eastern bluffs of Federal Way, between Adelaide and the northeastern limit of the study area. It is common to observe groundwater seeping from the bluff face following prolonged heavy precipitation. Periods of high rainfall intensity and duration (especially during saturated soil conditions) are another trigger of coastal landslides (Tubbs 1974, Thorsen 1987), such as those observed at New Years 1996-97 (Gerstel et al. 1997, Shipman 2001).

Surface water volumes often increase and become more focused within ditches and across impervious surfaces as a result of development of housing and roads. This is due to decreased infiltration and interception of water. Concentrated surface water can locally erode bluff crests while also saturating soils, which exacerbates "natural" slope stability problems along coastal bluffs and can trigger landslides (Shipman 2004). Runoff flowing down a driveway and rapidly across a lawn (which can absorb little water when wet) as sheet flow to the bluff face is an example of this process. Failed tightlines on a bluff face, constructed out of inexpensive and low-strength corrugated pipe to re-route surface runoff, can clog or break, initiating coastal landslides in King County.

Removal of bluff vegetation that results in a loss of root density and strength typically increases the likelihood of future landslides (Schmidt et al. 2001, Zeimer and Swanson 1977, Bishop and Stevens 1964). Bluffs with significant modifications to both the natural drainage regime and vegetation pattern are particularly susceptible to landsliding. Reestablishment and maintenance of native vegetation cover or installation of a fibrous-rooted vegetation cover along with some type of drainage control can reduce the likelihood of the bank failures (Gray and Sotir 1996, Menashe 2001, Roering et al. 2003).

The slope stability mapping in the Coastal Zone Atlas was recently digitized by the Washington State Department of Ecology (1979). The mapping was originally performed in the 1970s using aerial photograph analyses and field reconnaissance. Seven "recent landslides" (occurring in the preceding decade) were mapped in the Federal Way shoreline planning area, predominantly located in the western portion of the city, in reaches 1C and IB. Five historic landslides (prior to

1970) were also identified, three of which were located along the eastern shores, in reach 1A. The remaining slides were located in the western portion of the study area (reach 1C).

A combination of factors – including increased wave energy along shorelines, saturated soils from high precipitation levels, disturbance to the slope toe, and lack of bluff vegetation – can lead to coastal bluff landslides, especially when associated with storm events or extreme high, high tides. Landslides can be naturally occurring or accelerated by man-made disturbances to the coastal bluff.

3.4.1.4 Fluvial Influences on the Nearshore

Fluvial sources contribute to nearshore character and can act as an agent of change on the marine landscape. The quantity of fluvial sediment delivered to the nearshore depends up the nature of the hinterland: its elevation, the types of rocks and soil found there, the density of vegetation, and the climate (Komar 1976). The greater the volume of sediment, the greater influence on nearshore processes. In a regional, ecosystem-wide context, the fluvial influence on the Federal Way nearshore is negligible since none of the streams in Federal Way discharge significant volumes of sediment to Puget Sound.

3.4.1.5 Shore Modifications

A substantial portion of the Federal Way shoreline has been modified from its original state. Shoreline modifications observed within the study area include: riprap and revetments, bulkheads, fill, boat ramps and their associated footings. Figures 11-A, 11-B, and 11-C show approximately 38.4 percent of the linear shoreline has undergone such modifications, excluding filling which has not been formally inventoried (Johannessen et al. 2005). Modified shoreline segments vary in the degree that they are modified. Each form of shore modification alters nearshore ecosystem function or processes in some way.

Riprap, Revetments, and Bulkheads - Shore armoring or modifications that include covering the beach and/or backshore with riprap, a rockery, revetment or a bulkhead directly impact the nearshore. The effects of shore armoring on physical and biological processes have been the subject of much concern in the Puget Sound region (for example, Rice 2006). Macdonald, et al. (1994) completed a series of studies documenting the impacts to the beach and nearshore system caused by shore armoring at a number of sites. Additional studies on impacts from shoreline armoring have shown that in front of a bulkhead the suspended sediment volume and littoral drift rate all increased substantially compared to an adjacent unarmored shore (Miles 2001).

A bulkhead constructed near the ordinary high water mark (OHWM) in a moderate energy environment increases the reflectivity of the upper beach to waves substantially, causing backwash (outgoing water after a wave strikes shore) to be more pronounced. Increased backwash velocity removes beach sediment from the intertidal beach, thereby lowering the beach profile (Macdonald et al. 1994). A bulkhead constructed lower on the beach causes more impact. Construction of a bulkhead at or below OHWM results in coarsening of beach sediment in front of the bulkhead (Macdonald et al. 1994, Kraus 1988). Relatively fine-grain size sediment is mobilized by increased turbulence caused by the bulkhead (Miles 2001), and is preferentially transported away, leaving only the coarse material on the beach. This process also leads to the

removal of large woody debris (LWD) from the upper beachface. Both of these impacts lead to changes in habitat along the armored portion of shore.

A number of local hydraulic impacts often occur in response to a bulkhead. These include the formation of a scour trough (a linear depression) directly in front of the wall, probably as a result of increased reflectivity of the wave energy from the wall to the upper beach. Another hydraulic response is the formation of end erosion ("end effects"). This occurs at unprotected shores adjacent to the end of a bulkhead and is caused by wave refraction at the end of the bulkhead (Tait and Griggs 1991). "During storm" impacts, where seabed fluidization and scour occur at enhanced levels, may be pronounced in front of a bulkhead, but this process is not well understood.

The groundwater regime is often modified by the construction of a seawall along the base of a bluff (Macdonald et al. 1994). An impermeable bulkhead that extends vertically above OHWM raises the groundwater table. This can cause increased pore pressure in beach sediment, leading to mobilization of beach sediment under lower energy waves, relative to unbulkheaded conditions. This effect is most pronounced at locations with fine-grained beach sediment.

Of all the impacts of shore armoring in the Puget Sound area, sediment impoundment is probably the most significant negative impact (PSAT 2003, Pilkey 1988). Structures such as bulkheads, if functioning correctly, "lock up" bluff material that would otherwise be supplied to the shore drift system. This results in a decrease in the quantity of drift sediment available for maintenance of down-drift beaches. The negative impact of sediment impoundment is most pronounced when armoring occurs along a feeder bluff with a high sediment yield such as the bluffs approximately one-half mile east of Adelaide and in the western portion of the study area, just east of Dash Point State Park (Johannessen et al 2005, Macdonald et al. 1994). Additionally, the extent of cumulative impacts from several long runs of bulkheads is a subject of great debate in the coastal research and management communities.

A comparison of current and historical bluff conditions in King County documented that prior to modifications 49.5 percent of Federal Way shores were comprised of feeder bluffs (sediment sources). When compared with current conditions (37 percent), this represents a 25.2 percent loss of the total historic sediment sources in the Federal Way nearshore (Johannessen et al., 2005).

As the bluffs in the study area continue to gradually recede, there will likely be an increasing desire for homeowners to build bulkheads. This would lead to further sediment impoundment and further reductions in the natural sediment supplied to drift cells and nearshore habitats, and would therefore constitute a significant negative impact. Without this sediment, the beaches would become "starved," resulting in a reduction of the beach width and habitat degradation (Macdonald et al. 1994, Rice 2006). Beaches would also become more coarse-grained (Macdonald et al. 1994) as sand was winnowed out leaving a higher percentage of gravel. This would likely negatively impact forage fish spawning and other habitat values of county beaches (Rice 2006). This could also lead to an increase in coastal flooding and wave-induced erosion of existing low-shore armoring structures and homes.

Filling -Fill areas along the shores of Federal Way are not always obvious today; however, they quickly become apparent when comparing current and historic maps. For this purpose the U.S.

Coast and Geodetic Surveys' Topographic maps (T-sheets) were compared with USGS 7.5 minute topographic maps.

It appears that filling has taken place at several locations in Federal Way. The most obvious are at the estuaries in Dumas Bay and Dash Point State Park. The marsh in western Dumas Bay was historically considerably larger, but appears to have been reduced in size for residential development. The estuary in Dash Point State Park also appears to have been filled and channelized, possibly to reduce flooding and facilitate parking and recreational areas. Backfilling of bulkheaded shores appears to have occurred near Adelaide, where a historic accretion shoreform previously occurred, and at the base of bluffs east of Dash Point State Park.

3.4.2 Processes Affecting Freshwater Lake Shorelines

Ecosystem-wide processes that affect lake shorelines include specific actions related to hydrologic processes, sediment delivery, water quality and large woody debris. However, unlike large river systems where water flow is affected by factors across a greater watershed, lakes in Federal Way are located in the headwaters of drainage basins and are influenced by a limited area draining to these waterbodies. Lake processes are more easily altered by nearby land use modifications since they are directly tied to conditions in a smaller basin area.

Very limited information is available regarding toxins and pathogens within the freshwater lakes of Federal Way. Where available, this information has been included within the discussion water quality (Section 3.4.2.3).

3.4.2.1 Hydrology

Water naturally enters a watershed through rain, snow, or movement of groundwater. Water moves within a watershed by surface water flow in rivers and streams, infiltrates and becomes groundwater, or is stored in wetlands, lakes, and floodplains. In a natural system, the movement and storage of water is generally controlled by physical conditions such as climate, topography, land cover, and the permeability or infiltration capacity of soils and the underlying surficial geology (Stanley, et al., 2005).

Lakes in Federal Way have formed in shallow depressions remaining from glaciation on an upland plateau. These areas are in the headwaters of the drainage basin and are not affected by larger-scale ecosystem-wide processes occurring within the rivers in WRIA 9 and 10. The lakes in Federal Way are important for maintaining stream baseflow for down gradient streams and rivers.

Important areas for hydrologic processes affecting freshwater lakes in Federal Way include:

- Saturated areas or areas, which with low permeability provide overland or shallow subsurface flow;
- Lakes, low-gradient floodplains, and depressional wetlands, which provide surface water storage; and

- Topographic slope breaks or contact areas between geologic deposits of differing permeability, which provide groundwater discharge (i.e., return to surface flow) (Stanley, et al., 2005).

Hydrologic processes influence the following shoreline functions:

- Quantity and timing of flow affects hydrologic functions such as channel incision and flood storage;
- Quantity and timing of flow affects in-stream habitat functions such as channel complexity and habitat availability; and
- Groundwater flow affects hydrologic and hyporheic functions such as baseflow and temperature, as well as habitat and vegetation functions related to species diversity. Groundwater flow affects these functions in both riverine and wetland ecosystems.

3.4.2.2 Sediment Delivery

Sediment is naturally delivered to streams and river systems through surface erosion, mass wasting, and in-channel erosion. The delivery, movement, and storage of sediment is largely driven by hydrologic factors and generally controlled by physical conditions such as topography (gradient), land cover (vegetation), soil characteristics (erodibility), and the transport capacity or velocity of moving water (Stanley, et al., 2005).

Lakes in Federal Way do not naturally deliver sediment to downstream waterbodies, but rather serve as "sinks" for sediment from urbanized areas. As such these areas are more sensitive to urban development and inputs of sediment in surface water runoff.

Important areas for sediment delivery and movement in Federal Way include:

- Lakes, depresssional wetlands, floodplains, and depositional channels, which provide sediment storage (Stanley, et al., 2005).

Sediment processes influence the following shoreline functions:

- Sediment storage can protect downstream habitats from delivery of too much sediment input, which can adversely affect habitat.
- Increases in sediment delivery to lakes can surpass the lake's capacity to assimilate sediment and adversely affect habitat and water quality.

3.4.2.3 Water Quality

There are many processes at work that maintain or affect water quality in a watershed. This report focuses on the movement of phosphorus, toxins, nitrogen, and pathogens. Key processes include biotic uptake and decomposition, adsorption, and denitrification. The movement of water and sediment largely drives these processes, and they are generally controlled by physical characteristics such as biotic cover and composition, soil characteristics, and bacterial activity (Stanley, et al., 2005).

. Wetlands associated with the lakes or those that drain to the lakes in Federal Way serve to protect lake water quality through several mechanisms.

Important areas for water quality related processes in freshwater lakes include:

- Depressional wetlands with organic, mineral, or clay soils, which provide adsorption of phosphorus, toxins, and pathogens (fecal matter);
- High-permeability geologic deposits, which allow subsurface transport of pathogens while low-permeability deposits allow movement of pathogens via recharge;
- Depressional wetlands, which can both provide nitrogen (nitrification) and remove nitrogen (denitrification);
- Riparian areas with a consistent supply of shallow groundwater, which provide denitrification; and
- Headwater streams, which can provide biotic uptake and decomposition, and/or adsorption of nitrogen (Stanley, et al., 2005).

Water quality processes influence the following shoreline functions:

- Delivery and storage of nitrogen, phosphorus and toxins, and pathogens affect functions such as denitrification and nutrient cycling. Habitat functions such as invertebrate abundance and diversity, and food sources for fish, are also affected; and
- Delivery of nitrogen, phosphorus, and pathogens affects these functions in both riverine and wetland aquatic ecosystems.

3.4.2.4 Large Woody Debris

Large woody debris (LWD) consists of logs or trees that have fallen into a river or stream. In a natural system, LWD provides organic material to aquatic ecosystems and is considered a principal factor in forming stream structure and fish habitat characteristics. Riparian vegetation is the key source of LWD. Large woody debris is primarily delivered to rivers, streams, or wetlands by mass wasting, wind throw, or bank erosion (Stanley, et al., 2005).

Lakes in Federal Way are largely developed in residential uses and will not likely provide delivery of LWD as a key function. Lakes may deliver woody debris to stream outlets, but this is not an important function of the lakes in an urban setting. Delivery of LWD provides habitat function within the lakes themselves along the lakeshore supporting both inwater and riparian habitats.

Important areas for LWD delivery and movement in the lakes of Federal Way include:

- Forested areas adjacent to aquatic resources, which can provide LWD via windthrow; and
- Low-gradient channels, which provide storage of LWD and organic material, subject to the transport capacity of water (Stanley, et al., 2005).

The presence, movement, storage, and decomposition of LWD influence the following shoreline functions:

- Delivery of wood and organics affects vegetation and habitat functions such as lakeshore habitat structure and species diversity; and
- Riparian vegetation, especially LWD, provides habitat in the form of nesting, perching, and roosting as well as thermal protection, nutrients, and sources of food terrestrial insects) to a variety of wildlife species.

3.4.2.5 Shoreline Modifications

Lakes in Federal Way are most commonly influenced by surrounding development, which affects ecosystem processes. Some of the most common alterations that impact lakes include:

- Removing native shoreline vegetation;
- Removing mature trees in upland and nearshore areas;
- Construction of septic systems and drain fields
- Septic systems failures
- Armoring the shoreline using bulkheads;
- Increasing impervious surface area in the watershed;
- Increasing stormwater runoff into the lake;
- Altering shorelines in ways that encourage Canada geese and ducks to reside;
- Increasing fertilizer/pesticide runoff; and
- Increasing docks or other in-water structures.

These alterations affect shoreline processes through:

- Loss of habitat, shade, and insects which are important for fish;
- Increased sediment delivery, disturbing fish habitat and carrying pollutants;
- Increased wave action that can increase beach erosion rates;
- Loss of large woody debris for aquatic habitat;
- Decreased water quality from stormwater runoff;
- Increased nutrients and pathogens from excessive wildlife;
- Increased rates of invasive aquatic plant growth and algae blooms from increased nutrients through increased lake filling; and
- Increased water temperature leading to more algae blooms.

4.0 NEARSHORE/COASTAL PLANNING AREA INVENTORY

The purpose of this section of the report is to inventory and characterize conditions within the boundaries of the City's nearshore/coastal shoreline planning area in greater detail and in the context of the larger watershed, or landscape scale characterization of ecosystem wide processes. The intent is to identify how existing conditions in the shoreline planning area influence or contribute to alterations of processes that maintain aquatic ecosystems. The study area is shown on Figure 1 and subsequent figures as the City's shoreline planning area.

4.1 Physical Features

4.1.1 Coastal/Nearshore Processes and Modifications

The physical condition of the Federal Way coastal shores is the dynamic result of numerous influences including geology, shoreline orientation, bathymetry, fetch, geomorphology, and modification due to human development. Each segment of shore within the study area falls within a distinct littoral drift cell, which is composed of a sediment source, transport zone and depositional area (Figure 7). Sediment sources in the study area are predominantly eroding bluffs, commonly referred to as "feeder bluffs". Landslides and toe erosion commonly occur along these shores, where sediment is delivered to the nearshore and transported along shore by littoral drift. Smaller quantities of sediment are delivered to the nearshore by fluvial sources, though due to the small size of the streams and relatively low-flow, fluvial sediment sources in the area have only local effects on the nearshore. Transport zones are shores that are neither eroding nor accreting. Depositional areas, also referred to as accretion shoreforms, are typically located near the drift cell's terminus (Jacobsen and Schwartz 1981) and are associated with valuable habitats such as salt marshes, spits and pocket estuaries.

The width of the beach, and more specifically the backshore, influences bluff erosion rates. Wide beaches typically have a storm berm in the uppermost beach, or backshore, which functions to absorb wave energy and protect the base of the bluff from wave attack. Wave attack leads to toe erosion and bluff undercutting that destabilizes slopes. Where beaches are broad – due to littoral drift deposition, a recent influx of sediment, or proximity to a groin or other drift obstruction – bluff erosion and mass wasting may be locally reduced. Conversely, where beaches are narrow and sediment "starved" – due to either natural or artificial circumstances – the erosion rate of associated bluffs may accelerate (Shipman 2004).

Beach substrate is influenced by the geology of local sediment sources, wave energy and the position of the beach within the net shore-drift cell. Bluffs in the eastern study area are composed of larger sediment than bluffs located in the western area. As a result, beach material is finer at western beaches, relative to those in the eastern portion of the study area. Additionally, sediment size commonly becomes increasingly fine with increasing distance from the drift cell origin. (Johannessen et al., 2005)

Erosion control or shore protection structures are common in the study area. Residential or industrial bulkheading (also called seawalls) are typically designed to limit the erosion of the backshore area or bluff, but have numerous direct and indirect impacts on nearshore systems.

Studies of the impacts of shoreline armoring have documented increased suspended sediment and littoral drift rates along armored shores, relative to unarmored shores (Miles et al. 2001). Bulkheads constructed lower on the beach (below the OHWM) result in coarsening of beach sediment in front of the bulkhead (Macdonald et al. 1994). Relatively fine-grained sediment is mobilized by the increased turbulence caused by the bulkhead (Miles et al. 2001), and is preferentially transported away, leaving the coarser material on the beach.

Of all the impacts of shore armoring in the Puget Sound area, sediment impoundment is probably the most significant negative impact (PSAT 2003). Bulkheads, and similar structures, essentially "lock up" bluff material that would otherwise be supplied to the net shore-drift system. This results in a decrease in the quantity of sediment available for maintenance of down-drift beaches. The negative impact of sediment impoundment is most pronounced when armoring occurs along actively eroding bluffs (Johannessen et al. 2005, Griggs 2005). Over the long term, the construction of bulkheads on an erosional coast leads to the loss of beach area and complexity.

A recent study by Johannessen et al. (2005) mapped feeder bluffs, transport zones, accretion shoreforms and modifications along the reaches of the Federal Way study area. Landslides and toe erosion were also mapped throughout the study area. These data are summarized in Table 3. Mapping by Schwartz et al. (1991) mapped littoral drift direction throughout the study area. Table 4 displays net shore-drift direction, intertidal beach width, and sediment size.

Table 3. Shoretypes, Modifications and Landslides, and Toe Erosion

Shoreline Reach	Feeder Bluff Percent	Transport Zone Percent	Accretion Shoreform Percent	Modified Percent	Landslides Percent	Toe Erosion Percent
Puget Sound East (1A)	38	12	22	68	6	26
Dumas Bay (1B)	6	8	18	68	1	5
Puget Sound West (1C)	61	6	7	25	45	50

Source: Johannessen, MacLennan and McBride 2005.

Table 4. Net Shore-drift Direction, Sediment Size, Beach Width

Shoreline Reach	Net shore-drift direction	Sediment size	Beach width
Puget Sound East (1A)	West	Pebble with moderate sand	25-33 ft
Dumas Bay (1B)	Drift cell convergence. Southwest and Northeast	Sand with pebble	80-255 ft
Puget Sound West (1C)	West	Sand with minor pebble	75-100 ft

Source: Schwartz et al. 1991, Johannessen, MacLennan and McBride 2005, and Washington State DNR 2001.

The following section characterizes the physical conditions within each of the Federal Way shore reaches.

Puget Sound East (Reach 1A)

Sediment transport in the Puget Sound East reach is southwestward from the eastern boundary of the City limits and terminates at the southwestern corner of Dumas Bay. The northern orientation of the shoreline precludes exposure to predominant southerly wind and wave conditions and results in larger northerly wind waves driving net littoral sediment transport (net shore-drift; Schwartz et al. 1991). This shore is exposed to the greatest amount of fetch and/or wave energy throughout the study area.

This reach is characterized by high banks with varying levels of residential development (west of Redondo Beach), which lower to low bank south of Poverty Bay Park. Twenty-eight percent of the Puget Sound East shore is modified. Modified shores diminish in abundance in the southwestern portion of the reach. Modifications observed in the reach include bulkheads, riprap, and overwater structures.

Feeder bluffs account for approximately 38 percent of Puget Sound East shore length (Johannessen et al. 2005). These sediment sources are predominantly found in the central portion of the reach, likely due to the less modified state of the shoreline, enabling natural geomorphic processes to persist. Recent landslides were mapped along 5.9 percent, and recent toe erosion was active along 25.5 percent of the reach (Figure 7).

Geomorphic processes in this reach have been substantially altered by shoreline modifications. A recent study by Johannessen et al. (2005) shows that shoreline modifications have reduced the sediment sources in this shore reach by 23 percent of their historic prevalence.

Accretion shoreforms account for 21.8 percent of Puget Sound East. Each of these accretionary landforms is associated with a stream mouth or freshwater source (culverts). However, each has modifications that precluded the formation of subestuarine conditions. Beach sediment at these sites is sand with moderate pebble. The remaining shores within this reach are mapped as transport zones, neither substantially accreting nor eroding.

A typical beach profile in the Puget Sound East marine reach is composed of a mixed conifer and deciduous riparian buffer atop 80- to 100-foot-high, steep coastal bluffs. These bluffs are composed of Vashon advance outwash deposits and have a history of sliding. As a result, the base of the bluff is commonly armored with riprap. Upper beach sediment is predominantly sand with pebble, but at lower elevations clast size increases to pebble dominant. The beach is narrow, indicative of the erosive nature of these shores. Waterward of the beachface is a sandy low-tide terrace. (Johannessen et al. 2005)

Dumas Bay (Reach 1B)

Drift cells KI-9-2 and KI-10-1 converge in the southwest corner of Dumas Bay. The eastern portion of this marine reach encompasses the last mile (approximately) of KI-9-2, which originates just south of Saltwater State Park near the City of Des Moines. The western portion of

the reach includes the entire drift cell KI-10-1. This 0.3-mile cell exhibits southeastward drift and terminates at a recurved spit just northwest of the prograded beach in Dumas Bay (Figure 7).

The Dumas Bay reach is characterized by low to moderately high bank shores, with dense residential development, and abundant modifications. Higher bluffs are found in the western portion of the reach in cell KI-10-2. The beaches are wider and generally of more accretionary character relative to the other reaches, due to the drift cell convergence, multiple stream deltas and the protection afforded by the rounded headland on the west shore of the bay and by Maury Island to the north. Over two-thirds of the reach is modified with bulkheads or riprap. The eastern portion of the reach is near contiguously modified with several relict boat ramps and boathouse footings in the intertidal. Several of the beaches mapped as accretionary were also modified in the upper beach or backshore.

Feeder bluffs account for only 5.9 percent of this shore reach (Johannessen et al. 2005). These remaining sediment sources are exclusively found northeast of Joe's Creek (stream delta in the southeast corner of Dumas Bay), as well as on the southwest side of Lakota and Joe's Creeks. Toe erosion is mapped along 4.8 percent of the reach. Toe erosion is also mapped on the southwest side of both creeks. Only one landslide is mapped in Dumas Bay, which accounted for 0.6 percent of the reach.

Accretion shoreforms currently account for 18.2 percent of Dumas Bay, several of which are associated with a stream mouth. Fluvial-derived sediment contributes to accretionary condition of the beach. Broad sand flats and extensive backshores with driftwood and dune vegetation characterize these areas.

A typical beach profile in this reach consists of a 3- to 5-foot-high bank, residential dwelling with a bulkheaded backshore. An absence of backshore (storm berm and dune) habitats and marine riparian is a direct result of the density of residential development and a bulkheaded shore. Beach material is a mix of sand with moderate pebble. A broad sand flat extends below the high-tide beach. (Johannessen et al. 2005)

Puget Sound West (Reach 1C)

This reach originates at a drift zone divergence between cells KI-10-2 and KI-10-3 located at the headland on the west shore of Dumas Bay. KI-10-3 exhibits westward drift from the divergence zone to the drift cell terminus at Dash Point in Pierce County (Figure 7).

Puget Sound West is characterized by 80- to 200-foot–high, slowly receding (apparently through slumping) high bluffs with abundant large woody debris recruitment. Much of the Puget Sound West shoreline is encompassed within Dumas Bay City Park and Dash Point State Park. Areas not within the parks are easily identifiable due to residential development on top or at the base of the bluffs. Modifications are typically residential bulkheads constructed at the base of bluffs between the two parks. This is the only contiguously bulkheaded area in the reach and represents 25.3 percent of its length. Another very short shore modification is located at the western end of the study area.

Feeder bluffs are mapped throughout much of this shore reach, representing 60.9 percent of the segment (Johannessen et al. 2005). Thirteen recent landslide areas are mapped, most of which

are located along the high bluffs of the headland west of Dumas Bay and surrounding Dash Point State Park. In total, landslides are mapped along 44.6 percent of this reach. Recent toe erosion is also frequently observed, accounting for 49.7 percent of the reach.

Few transport zones are mapped in this reach, accounting for only 6.4 percent of the reach. Accretion shoreforms are also relatively infrequent. These are exclusively found in the western portion of the reach, adjacent to the mini-estuary in Dash Point State Park. Most of this accretion shoreform is unmodified; however, the stream channel is heavily riprapped.

Geomorphic processes in this reach have been substantially altered by shoreline modifications. A recent study by Johannessen et al. (2005) shows that prior to modifications sediment sources accounted for 84.6 percent of the reach. This indicates that shoreline modification has resulted in a 23.7 percent (2,066 feet) loss of the available sediment sources in the reach.

A typical cross section of the Puget Sound West reach includes a mixed conifer and deciduous forested bluff with slumps and jack strawed trees hanging over the intertidal area. Toe erosion has scoured beneath some trees, leaving them growing over the intertidal area while still attached to the toe of the bluff. Drift logs are caught and accumulate in these trees. Beach material is almost exclusively sand with minor amounts of pebble. The low-tide beach includes a broad sand flat. (Johannessen et al. 2005)

4.1.2 Geological Hazards and Shoreline Slope Stability

4.1.2.1 Seismic Hazard Areas

Seismic hazard areas are defined in Chapter 18-28 of the Federal Way Municipal Code (FWMC) as those areas subject to earthquake damage as a result of seismically-induced ground shaking, slope failure, settlement or soil liquefaction, or surface faulting. These conditions commonly occur in areas underlain by cohesionless soils of low density, usually in association with a shallow groundwater table (Palmer et al., 2003). No seismic hazard areas are identified within the shoreline jurisdiction in the King County Sensitive Areas Map Folio (King County, 1990) or on the county's interactive map site (iMAP) (accessed on 5/16/06 at http://www.metrokc.gov/gis/mapportal/iMAP_main.htm). However, maps produced by the Washington Department of Natural Resources indicate areas of low to moderate liquefaction susceptibility in all shoreline segments (Palmer et al., 2003).

4.1.2.2 Landslide Hazard Areas

Landslide hazard areas are defined in Chapter 18-28 of FWMC as those areas potentially subject to episodic downslope movement of a mass of soil or rock. They are defined as: (1) any area having a combination of slopes greater than 15 percent, permeable soils overlying impermeable soils, and springs or groundwater seepage, (2) any area showing movement during the last 10,000 years, (3) any potentially unstable area as a result of stream incision or wave erosion, (4) any area located in a ravine or on an alluvial fan that may be inundated by flooding or debris flows, (5) any area identified by the Natural Resources Conservation Service as having a severe limitation for building site development, (6) any area mapped as unstable by the Department of Ecology, or (7) slopes having gradients greater than 80 percent.

Landslide hazard area information for the City's shoreline jurisdiction is shown on Figures 9-A through 9-C. Designated landslide hazard areas include the majority of the shore bluffs in all of the shoreline segments. As much as 77 percent of the shoreline Reach 1C is considered to be a landslide area, while 47 and 38 percent of Reaches 1A and 1B, respectively, are considered to be landslide hazard areas. The extent of designated landslide hazard areas may not correspond exactly with the mapped extent of mass wasting deposits, as shown on Figure 4, or with the slope stability and landslide area designations indicated in the Coastal Zone Atlas.

4.1.2.3 Erosion Hazard Areas

Erosion hazard areas are defined in Chapter 18-28 of FWMC as those areas having severe to very severe erosion hazard because of natural agents such as wind, rain, splash, frost action or stream flow. Such areas designated on City GIS maps and King County GIS maps (accessed on 5/16/06 at http://www.metrokc.gov/gis/mapportal/iMAP_main.htm) include all coastal bluffs and steep slopes within the jurisdiction, which includes all shoreline segments. Approximately 65 to 70 percent of the shoreline segments are considered erosion hazard areas. These areas are shown on Figures 9-A through 9-C.

4.1.2.4 Steep Slopes

Steep slope hazard areas are defined in Chapter 18-28 of FWMC as those areas with a slope of 40 percent or greater and with a vertical relief of 10 or more feet, a vertical rise of 10 feet or more for every 25 feet of horizontal distance. According to City GIS maps King County GIS maps (accessed on 5/16/06 at http://www.metrokc.gov/gis/mapportal/iMAP_main. htm), the shoreline bluffs in all segments of the jurisdiction qualify as steep slopes, as shown on Figures 9-A through 9-C.

4.1.2.5 Shoreline Slope Stability

The Department of Ecology Coastal Zone Atlas (Ecology, 1979) characterizes the slope stability of the entire shoreline along Puget Sound. Although the City does not regulate shoreline development based on slope stability characterization, the maps provide an additional characterization of slope stability and a source of documented landslides. This mapping should not be considered comprehensive and does not include landslides that have occurred since the late 1970s.

In the Coastal Zone Atlas, slope stability is defined in terms of six separate categories: stable, intermediate, unstable, unstable recent landslide, unstable old landslide, and modified. Table 5 describes these slope stability categories.

Table 5. Ecology Slope Stability Map Designations

Slope Stability Designation	Definition
Stable	Generally rise less than 15 percent in grade, except in areas of low groundwater concentration or competent bedrock. Include rolling uplands and lowlands underlain by stable material (i.e., unweathered till and/or peat deposits) with no significant slope.
Intermediate	Generally steeper than 15 percent except in areas where weaker material and/or abundant material exist. These areas include slopes of sand and gravel, till, or thin soils over bedrock with no known failures.
Unstable	Slopes that are considered unstable due to geology, groundwater, slope, and/or erosional factors which include areas of landslide and talus too small or obscure to be mapped.
Unstable Recent Landslide	Recent or historically active landslide areas (based on surveys conducted in the late 1970s).
Unstable Old Landslide	Post-glacial but prehistoric landslide areas.
Modified	Slopes that are highly modified by human activity and include areas of significant excavation or filling. Response of the slope to a combination of human activity and natural processes may be unpredictable.

Slopes classified as unstable are present in all segments of the shoreline jurisdiction according to the Department of Ecology Coastal Zone Atlas (Ecology, 1979). Slopes within Reach 1A are generally designated in the Coastal Zone Atlas as unstable, unstable recent landslide, unstable old landslide, and intermediate. Along the shoreline of Dumas Bay, Reach 1B, slopes are designated unstable, unstable old landslide, and intermediate. Shorelines within Reach 1C are characterized by unstable old landslide, intermediate, and stable.

4.1.3 Aquifer Recharge Areas

Critical aquifer recharge areas are defined in WAC 365-190-030 as "areas in which water reaches the zone of saturation by surface infiltration. These areas are hydrogeologically susceptible to contamination and contamination loading potential including but not limited to such areas as sole water source aquifer recharge areas, special protection groundwater management areas, wellhead protection areas, and other areas with a critical recharging effect on aquifers used for potable water." Chapter 22, Article XIV, Division 9 of the Federal Way City Code, "Critical Aquifer Recharge Areas and Wellhead Protection Areas," applies to any development activity or division of land, which requires review under FWCC Chapter 18, "Environmental Protection." The Lakehaven Utility District has mapped generalized aquifer recharge areas. There are three major aquifers in the City and its PAA, but only one intersects any shoreline planning areas. The Redondo/Milton Channel Aquifer overlaps portions of reach 1A, 1B, and 1C. This area is managed as A Critical Aquifer Recharge Area. The City has mapped wellhead protection zones within the city limits and the PAA. The majority of the wellhead protection areas do not coincide with the shoreline reaches, and no wellhead protection areas coincide with the three marine shoreline reaches.

4.1.4 Flood Hazard Areas

Flood hazard areas are typically identified on the Federal Emergency Management Agency (FEMA) flood insurance rate maps as the 100-year floodplain. All coastal beaches within the City's jurisdiction are included within the 100-year floodplain (King County, 2002, from FEMA FIRM mapping). Coastal floodplain hazard areas are typically associated with storm waves.

4.1.5 Streams

Streams are defined in the FWCC Chapter 22 Article I Section 22-1 and are classified as "Major" or "Minor" streams. Major streams include any stream or tributary that contains or supports, or which under normal circumstances contains or supports resident or migratory fish and are perennial. Minor streams are those typically smaller streams that do no meet the definition of a "major" stream, may be ephemeral. Streams within the City of Federal Way have been evaluated and classified in a citywide inventory conducted in 2001 (URS). Streams provide valuable wildlife corridors, a source of fluvial sediments to the marine shoreline (moved along the shoreline by currents), and support a range of fish species. The City of Federal Way is located in Water Resource Inventory Area (WRIA) 9, the Duwamish-Green River and Central Puget Sound Watershed. Information on stream conditions was drawn in particular from the following documents: *Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island)* (Kerwin and Nelson, 2000), and *A Catalog of Washington Streams and Salmon Utilization - Volume I, Puget Sound Region* (Williams et al., 1975).

Several streams have been identified in Federal Way that flow directly into Puget Sound and are part of the Lower Puget Sound basin. The streams discussed below are shown in Figure 6.

Puget Sound East

Four short unnamed streams enter the coastal shoreline in Reach 1A. These streams have steep gradients and are associated with landslide and erosion hazard zones. The city stream inventory considers these streams as Major streams. These streams are important contributors of fluvial sediment transport to the marine environment in the City of Federal Way. Major streams in the City are afforded a standard buffer of 100 feet.

Dumas Bay

Three streams drain to the shoreline within the Dumas Bay area, or Reach 1B; these include Joe's Creek, Lakota Creek and an unnamed tributary to the Sound (Dumas Bay Creek). Joe's Creek and Lakota Creek are Major streams and Dumas Bay Creek is considered a Minor stream.

Joe's Creek originates in the uplands of Federal Way, flowing through Olympic View Park and the Twin Lakes Golf Course, then drops into a high-gradient stream channel that falls through a wooded ravine, eventually flattening immediately prior to entering Puget Sound on the east side of Dumas Bay. The substrate within the creek consists of pebbles and cobble-sized particles with localized sand depositions. Gravel deposits are very local and spawning opportunities are typically few. These features are typical of flow alterations caused by undetained stormwater (King County, 2000). Joe's Creek appears on the 2004 Department of Ecology 303(d) list for

fecal coliform (data collected in 1988 from monitoring station at SR 509). The source of fecal coliform in Joe's Creek is unknown.

Lakota Creek flows in a northwesterly direction before entering Puget Sound at Dumas Bay (Reach 1B). The stream passes through the site of the Lakehaven Sewage and Wastewater Treatment Plant, prior to flowing to the Puget Sound. The lower reach of the stream was relocated as part of an upgrade to the sewage treatment plant in 1987. The creek generally flows through residential areas and alongside roads. The riparian habitat in the lower reaches consists of small deciduous trees with a shrub understory. The lower mile of creek supports dense stands of conifers within a moderate- to high-gradient ravine. Substrate within Lakota Creek is generally the same as that in Joe's Creek. It was on the 1998 303(d) list for fecal coliform (King County, 2000), but is not listed on the 2004 303(d) list.

Puget Sound West

One unnamed creek (referred to in the WRIA as No. 0391) flows through a steep ravine into Puget Sound at Dash Point State Park in Reach 1C. Clay bluffs border the beach in many places. Mudslides have become more frequent in the stream with increasing development (KCDNR, 1998). From aerial photography (2002), riparian buffer vegetation appears to be largely intact in the upper reaches within Dash Point State Park, but less so from the parking lot down to the creek mouth. The creek banks are armored from the mouth up to the road bridge, 200 feet upstream (WRIA 9, 2005).

4.2 Biological Resources

Biological resources described in the coastal shorelines encompass wetlands, critical wildlife habitat and species, marine riparian habitats, marine intertidal habitats, and priority species.

4.2.1 Wetlands

Wetlands near the Puget Sound shoreline typically include tidal marshes and tidally influenced estuaries. Tidal marshes include salt and freshwater habitats that experience tidal inundation (KCDNR, 2001). Several wetlands have been mapped by various sources in the City's coastal shoreline jurisdiction (Figure 6). According to the 1987 National Wetlands Inventory (NWI), the entire area of the City's shoreline jurisdiction in the City limits is designated as Estuarine Intertidal Unconsolidated Shore wetland or Estuarine Intertidal Aquatic Bed and Unconsolidated Shore wetland (USDI, 1987a and 1987b). In addition, one larger freshwater wetland is mapped at Dumas Bay as a Palustrine Emergent Scrub/Shrub wetland. The King County Sensitive Areas Map Folio (King County, 1990) does not identify any wetlands within the City's marine shoreline jurisdiction.

The City Wetland Inventory (City of Federal Way, 1998) identifies the freshwater wetland at Dumas Bay as a Class I wetland (FWMC 18-28). However, it does not include the estuarine wetlands identified in the NWI within the City's marine shoreline jurisdiction. Although mapped as wetlands at the national level on the NWI maps, the intertidal areas are likely not sufficiently vegetated to meet the definition of wetland at the state or local level. Additional marine shoreline jurisdiction wetlands are identified in the City's Wetland Inventory northeast of

Dumas Bay near the intersection of Southwest 300th Place and 30th Avenue Southwest and two within the conservancy area north of Southwest 295th Street between 9th and 10th Avenues Southwest. All of these wetlands are less than 1 acre in size and are identified as Class III (FWMC 18-28).

Parks and open spaces including Dash Point State Park, Poverty Bay Park, and Dumas Bay Park create significant breaks in residential development along the City's marine shoreline. Of the roughly 25,000 feet of marine shoreline within the City's jurisdiction, approximately 40 percent is armored. The majority of the unarmored shoreline is within the park and open space conservation areas, with some of the developed private shoreline also without armoring. Development and armoring along marine shoreline reaches within the City's jurisdiction have eliminated historical wetlands and prevent connections between interior wetlands and the nearshore area.

4.2.2 Critical Wildlife Habitat and Species

Critical fish and wildlife habitat areas are those areas identified as being of critical importance in the maintenance and preservation of fish, wildlife and natural vegetation. Critical fish and wildlife habitat areas are defined in Chapter 18.28 (FWMC) as follows:

> *Fish and wildlife habitat conservation area shall mean the management of land for maintaining species in suitable habitats within their natural geographic distribution so that isolated subpopulations are not created. Habitat conservation areas include but are not limited to such areas as: areas with which endangered, threatened, and sensitive species have a primary association; habitats and species of local importance; commercial and recreational shellfish areas; kelp and eelgrass beds; herring and smelt spawning areas; naturally occurring ponds under 20 acres and their submerged aquatic beds that provide fish or wildlife habitat; waters of the state; lakes, ponds and streams planted with game fish by a governmental or tribal entity; state natural area preserves and natural resource conservation areas; and streams.*

Mapped critical fish and wildlife habitats are shown on Figure 10. Critical fish and wildlife habitats in the City's marine shoreline planning area are characterized throughout the following sections describing the shoreline and nearshore biological areas.

4.2.3 Marine Riparian Habitats

Riparian areas are transitional zones between terrestrial and aquatic ecosystems. Riparian habitats include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (Brennan and Culverwell, 2004). Marine riparian vegetation is defined as vegetation overhanging the intertidal zone (KCDNR, 2001). Marine riparian zones function by protecting water quality; providing wildlife habitat; regulating microclimate; providing shade, nutrient and sources of food; stabilizing banks; and providing large woody debris (Anchor Environmental and People for Puget Sound, 2002).

Marine riparian zones were examined through limited field reconnaissance and review of 2001 oblique aerial photos (Ecology, 2002). Marine riparian vegetation within the City's shoreline planning area was mapped in the *WRIA 9 Marine Shoreline Inventory Report* (Anchor, 2004).

Puget Sound East

Riparian vegetation in Reach 1A is mixed trees and grasses. Much of Reach 1A is armored with concrete and wooden bulkheads, and riprap seawalls. LWD or drift log accumulations have been mapped along unarmored portions of Reach 1A.

Dumas Bay

Riparian vegetation within the Dumas Bay reach, Reach 1B, is dominated by grasses, although trees are found along the high bluffs to the west of Dumas Bay, as well as in the reach between Joe's Creek and Lakota Creek. The shoreline is armored for approximately 600 feet east of Dumas Bay Park, as well as east of Lakota Creek to Poverty Bay Park for the protection of homes along the toe of the bluff. LWD is lacking along most of this shoreline segment, though drift log accumulations have been mapped along the beach at Dumas Bay Park.

Puget Sound West

Trees dominate the riparian vegetation in Reach 1C, particularly along Dash Point State Park and the high, steep bluffs along this segment. Shoreline armoring is limited to the center of this reach, along the rural segment. This armored section is generally lacking in LWD and drift logs, although LWD is available along much of the rest of the shoreline segment.

Shoreline activities that may negatively affect marine riparian areas (Brennan and Culverwell, 2004) include:

- Fecal and chemical contamination from failing septic systems, lawn chemicals, and stormwater;
- Loss of vegetation from shoreline armoring, clearing and grading activities, or tree removal for view corridors; and
- Wildlife habitat infringement due to increased ambient light levels at night, fragmentation from road crossings, noise from human activity, and domestic pets.

4.2.4 Marine Intertidal Habitats

Marine intertidal habitats include flats, subestuaries, eelgrass beds, and kelp forests. These areas are considered "special aquatic sites, "which are special habitats in the intertidal zone that generally do not meet the definition of wetland. Flats generally include gently sloping (less than 5° slope) sandy or muddy intertidal or shallow subtidal areas (KCDNR, 2001), and are used by juvenile salmonids, shorebirds, and shellfish, among other species. Flats are generally located at the mouths of streams where sediment transported downstream is deposited, and in areas of low wave and current energy where longshore waves and currents deposit sediment (KCDNR, 2001). All of the flats in WRIA 9 were mapped around Vashon and Maury Island; however, there are tidal flats in WRIA 9 that were not captured during the WDNR mapping effort. Sand and gravel

flats are located near the mouth of Unnamed Creek (#0391) that enters Puget Sound through Dash Point State Park (Reach 1C), and Dumas Bay (Reach 1B).

Shoreline activities that may impact tidal flats (KCDNR, 2001) include:

- Unnatural erosion or deposition of sediment;
- Harvesting of shellfish and other marine life;
- Fecal and chemical contamination from on-site septic systems, lawn chemicals, and stormwater;
- Physical disturbances from shoreline armoring, marina construction, and upland development practices;
- Shading from overwater structures; and
- Loss of emergent and riparian vegetation.

Subestuaries are those areas of river and stream mouths that experience tidal inundation, including their deltas and any associated marshes (KCDNR, 2001). Subestuaries form where the stream or river broadens and fresh and saltwaters mix. Subestuaries function to attenuate flooding, provide juvenile salmonid feeding and rearing habitat, act as a transition area for migrating adult salmonids, support eelgrass beds (depending on salinity), and provide refuge, feeding, and production areas to a wide variety of birds, fish, mammals, and invertebrates (KCDNR, 2001). Subestuaries, especially those rich in organic matter, can support numerous and diverse marine and estuarine invertebrates such as polychaete worms and amphipods. These organisms near the base of the food web can be key to overall ecosystem productivity and habitat value for fish, birds, and mammals. Subestuaries occur in marine shoreline Reaches 1B and 1C, and are associated with the stream mouths of Unnamed Creek (#0391), Joe's Creek, and Lakota Creek.

Deltas are formed by downstream sediment transport. The growth of deltas and quality of habitat provided by the subestuaries is influenced by annual rainfall and the rate at which sediment is transported and deposited at the mouths of streams. High peak flows that occur as a result of increased impervious surface within the stream basin likely transport sediment further out into Puget Sound where depths are greater, resulting in sediment accumulation beyond the stream mouth.

Shoreline activities that may affect subestuaries include:

- Physical disturbances from shoreline armoring;
- Physical disturbances from dredging and filling;
- Changes in hydrology due to increased impervious surface within stream basins; and
- Nonpoint pollutant runoff from impervious surfaces and residential lawns near the shoreline.

The importance of eelgrass has been described in various sources, including the *Reconnaissance Assessment of the State of the Nearshore Environment* (KCDNR, 2001). Eelgrass beds are found

in shallow subtidal areas and provide feeding and rearing habitat for a large number of marine organisms. Eelgrass beds have been documented within the City's shoreline jurisdiction in all marine shoreline segments. Continuous eelgrass distribution can be found along the north end of Dash Point State Park and Palisades Park, as well as from the north end of Dumas Bay to 3rd Avenue Southwest; eelgrass distribution along the remainder of the City's marine shoreline is classified as patchy (WDNR, 2001). Shoreline activities that may impact eelgrass (KCDNR, 2001) include:

- Clam harvesting;
- Propeller scour and wash;
- Physical disturbances from shoreline armoring;
- Shading from overwater structures; and
- Physical disturbances from dredging and filling.

The function of kelp has been described in *Reconnaissance Assessment of the State of the Nearshore Environment* (KCDNR, 2001). Kelp provides habitat for many fish species, including rockfish and salmonids, potential spawning substrate for herring, and buffers to shoreline from waves and currents, among other functions. Kelp distribution is largely dependent upon the type of substrate, generally attaching to rocky substrates. In areas where there is a coarsening of substrate in the low intertidal and shallow subtidal zones, there is a more likely occurrence of kelp. A change in kelp distribution may indicate the coarsening of shallow subtidal sediments (such as that caused by erosion related to a seawall) or an increase in nutrient loading (such as from sewage effluent). Kelp forests are not currently mapped within the City of Federal Way shoreline planning area. Kelp was previously reported as occurring within all reaches of WRIA 9, which would include the Federal Way shoreline (KCDNR, 2001). KCDNR also noted data gaps in general knowledge of kelp and its biology, its role in nearshore ecological processes, lack of historical or recent studies, and lack of distribution data.

Shoreline activities that may impact kelp densities (KCDNR, 2001) include:

- Physical disturbances from shoreline armoring, marina construction, and harvesting;
- Shading from overwater structures;
- Beach nourishment; and
- Nutrient loading.

4.2.5 Priority Habitat and Species

The Washington Department of Fish and Wildlife (WDFW) maintains priority habitat and species information for Washington State, including the status of species as threatened or endangered. The City of Federal Way occurs within the WDFW Region 4. Priority habitats within Region 4 include consolidated marine/estuarine shorelines, cliffs, caves, snags, riparian areas, old-growth/mature forests, and urban open spaces. The following sections discuss some of the priority species and species of local importance that occur within the City's shoreline planning area.

4.2.5.1 Shellfish

Geoduck clams (*Panopea generosa*) are documented in subtidal areas adjacent to shoreline in a small portion of Reach 1A, as well as all of Reaches1B and 1C, southwest of Poverty Bay Park and extending beyond the City limits (Figure 10). The tract was last surveyed in 1971, as reported in Sizemore and Ulrich (2000). At the time of the 1971 survey, densities within the tract and other geoduck tracts along the WRIA 9 mainland area were shown to be amongst the highest in Puget Sound (approximately 4 to 7 per square meter). The tracts, however, were also reported as "polluted or possibly polluted" (Sizemore and Ulrich, 2000). Since 1971 the shoreline has continued to be developed which has an effect on the shellfish populations and their distribution. No doubt pollution will continue to be an issue. Additional surveys are needed to confirm species abundance and health.

In general, shellfish populations are relatively low in all shoreline reaches. Population data from a series of shoreline surveys along the southern extent of WRIA 9 (south of Mee Kwa Mooks Park of Seattle to Dash Point State Park) were analyzed by KCDNR (2001), and are presented in Table 6. It should be noted that there is a data gap concerning the collection of population data, and this relates primarily to the differences in sampling methodology and lack of recent quantitative population studies within WRIA 9.

Table 6. Shellfish Population Densities in Southern WRIA 9

Common Name	Scientific Name	Population density (number per square meter)
Butter clam	*Saxidomus giganteus*	<10
Native littleneck clam	*Protothaca staminea*	6-17
Manila clam	*Tapes philippinarum*	≤10
Geoduck	*Panopea generosa*	1-2
Dungeness crab	*Cancer magister*	N/A; decreases as you move south from Seattle
Olympic oyster	*Ostrea lurida*	0
Northern abalone	*Haliotis kamtschatkana*	0

No portion of the City's shoreline is currently used for commercial shellfish harvest. In July 2004 the Washington State Department of Health closed all of the Puget Sound shoreline in King County, including Dash Point State Park, Dumas Bay Park and Poverty Bay Park, to recreational shellfish harvesting for all species due to pollution advisory and the presence of biotoxins in particular shellfish species. The Department of Health conducts an ongoing assessment of pollution and conditions related to shellfish harvesting. The latest update was in March 2006, which maintained the closure of mainland King County beaches to recreational shellfish harvesting (Washington Department of Health, 2006).

4.2.5.2 Salmonids

The WDFW *SalmonScape* database (WDFW, 2006), PHS Data, as well as *A Catalog of Washington Streams and Salmon Utilization - Volume I, Puget Sound Region* (Williams et al., 1975), identify the known presence of salmon in local streams. Two creeks in Reach1B have documented presence of PHS fish, Joe's Creek and Lakota Creek. Joe's Creek contains documented coho salmon and Chum. Lakota Creek has documented use by coho and chum salmon.

Nearshore habitat is an important environment for juvenile salmonids, where the shallow water depth obstructs the presence of larger predator species (Kerwin and Nelson, 2000). All shoreline segments within the City's shoreline jurisdiction are known or expected to contain juvenile salmonids including bull trout, cutthroat, Chinook, chum, coho, pink, and sockeye salmon based in the knowledge of species life histories (KCDNR, 2001).

Critical Habitat, as defined by the Endangered Species Act, "is the specific areas within the geographical area occupied by a species…on which are found those physical or biological features essential to the conservation of the species and that may require special management considerations or protection"; and "specific areas outside the geographical area occupied by a species at the time it is listed… that are essential for the conservation of the species." Critical Habitat has been designated for Pacific salmon and steelhead in Washington, Oregon, and Idaho, including the Puget Sound Evolutionarily Significant Unit (ESU) Chinook salmon. Areas within Federal Way that are included as Chinook Critical Habitat include West Hylebos Creek, and estuarine, and nearshore marine areas to a depth of 30 meters relative to Mean Lower Low Water (MLLW) (Federal Register, 2005a). Critical Habitat has also been designated for bull trout, which may be present in the nearshore areas of Federal Way. Designated Critical Habitat for bull trout includes marine waters to a depth of 33 feet (10 meters) relative to MLLW (Federal Register, 2005b).

Nearshore modifications, as detailed in Sections 4.1, 4.2.3, and 4.2.4 of this chapter, affect salmonid habitat (Redman et al., 2005) in the following ways:

- Loss and/or simplification of deltas and delta wetlands, which provide forage and rearing habitat for salmonids;
- Alteration of flows through major rivers;
- Modification of shorelines by armoring, overwater structures and loss of riparian vegetation;
- Contamination of nearshore and marine resources;
- Alteration of biological populations and communities;
- Transformation of land cover and hydrologic function of small marine surface water discharges via urbanization; and
- Transformation of habitat types and features via colonization by invasive plants.

These nearshore modifications can adversely affect salmonid habitat by reducing forage and rearing habitat for young fish, changing flow dynamics in rivers and altering in-stream habitat,

reducing water quality, creating blockages for fish passage, and altering the food supply upon which salmonids depend.

4.2.5.3 Forage Fish

Forage fish include species that as adults breed prolifically and are small enough to be prey for larger species. They are often non-game fish. The three forage fish species most likely to occur in the City's shoreline jurisdiction include surf smelt, sand lance, and Pacific herring (Figure 10). Different species utilize different parts of the intertidal and subtidal zones, with sand lance and surf smelt spawning primarily in the substrate of the upper intertidal zone, and Pacific herring spawning primarily on intertidal or subtidal vegetation (Lemberg et al., 1997). Information on the five potential forage fish species within the City marine shoreline is summarized in Table 7.

Table 7. Forage Fish Species

Species	Documented Presence	Spawning Timing	Preferred Spawning Substrate	Spawning Location
Pacific herring	None (nearest is Quartermaster Harbor on Vashon I.)	Quartermaster Harbor stock spawn January through mid-April	Eelgrass	Upper high tide limits to depths of 40 feet (typically between 0 and –10 tidal elevation)
Sand lance	Yes, WDFW PHS	November 1 to February 15	Fine sand, mixed sand and gravel, or gravel up to 3cm	From + 5 tidal elevation to higher high water line (from bays and inlets to current-swept beaches)
Eulachon	None	Late winter/early spring	Unknown	Freshwater streams
Longfin smelt	None	Winter	Sand with aquatic vegetation	Freshwater streams
Surf smelt	Yes, WDFW PHS	South Puget Sound stocks are fall-winter spawners (September to March)	Mix of coarse sand and fine gravel (1-7mm)	Upper intertidal

Sources: (O'Toole, 1995; KCDNR, 2001; Lemberg et al., 1997)

Information on documented forage fish spawning activity was available from the Washington Department of Fish and Wildlife Priority Habitat Species (WDFW PHS) data (2004). No Pacific herring, eulachon, or longfin smelt spawning areas are currently documented in the shoreline inventory area (WDFW, 2004). However, it is fair to assume that they all utilize the nearshore areas for feeding and migration. WDFW (2004) and Kerwin and Nelson (2000) document surf smelt spawning areas in a small stretch of Reach 1A, adjacent to Southwest 296th Street between 9th and 12th Avenues Southwest and in a segment of Reach 1C and from the western edge of Dash Point State Park to beyond the City's western shoreline boundary. A sand lance spawning area is mapped from just inside the eastern boundary of the City (Reach 1A) and continuing northeast across the mouth of Redondo Creek (Kerwin and Nelson, 2000; WDFW, 2004).

Nearshore modifications affect forage fish habitat in the following ways:

- Development impacts the shoreline, particularly marinas and boat ramps, which bury spawning habitat, introduce the potential for repeated disturbance, and potentially alter nearshore hydrology;
- Sewer outfalls introduce pollutants and nutrients to the nearshore;
- Overwater structures shade intertidal vegetation and may alter nearshore hydrology;
- Riprap revetments and bulkheads impound sediment in bluffs such that fine-grained spawning beach sediment is not replenished (ongoing net-shore drift decreases spawning habitat); and
- Riprap revetments and vertical bulkheads alter nearshore hydrology and may increase wave energy on intertidal areas.

Sand lance and surf smelt spawn in the upper intertidal zone of protected sand-gravel beaches throughout the increasingly populated Puget Sound basin, making these species vulnerable to the cumulative effects of various types of shoreline development. "No net loss" regulations for protection of known spawning sites of forage fish species are included in the Washington Administrative Code Hydraulic Code Rules (WAC 220-110), which are applied during permitting of in-water construction activities.

4.2.5.4 Marine Mammals

Seals, sea lions, whales, and dolphins may all be observed off the shores of Federal Way. Seals and sea lions use specific shoreline areas, known as haul-outs, to haul-out of the water and rest, dry out, interact and regulate body their temperature. In addition to resting, harbor seals give birth to and nurse their pups at certain haul-out locations, and undergo an annual molt of their pelage or fur. Haul-outs can include beaches, rocky areas, log booms, and floats. Some haul-outs are used regularly, while others may be used seasonally or occasionally. No seal or sea lion haul-outs have been documented in Federal Way, although they have been documented on buoys, floats, and logbooms in Commencement Bay and southeast of Maury Island (Jeffries et al., 2000).

Whales and dolphins known to regularly visit central Puget Sound include southern resident killer whales, common dolphin, harbor porpoise, and Dall's porpoise. They do not typically use the nearshore areas within City of Federal Way shoreline jurisdiction. Critical Habitat has been proposed for killer whales, including Puget Sound marine waters deeper than 20 feet (6.1 meters) (Federal Register, 2006).

4.2.5.5 Shorebirds and Upland Birds

Adjacent to the open waters of Puget Sound, the upland terrestrial environment provides habitat for birds, amphibians, reptiles, and insects. A variety of shorebirds utilize the nearshore environment for wintering and breeding. Seventy-five species of birds are associated with marine nearshore environments in Washington (O'Neil et al., 2001).

Great blue heron (*Ardea herodias*) and green heron (*Butorides striatus*) nesting colonies have been identified in Reach 1B (WDFW, 2006). Documented observation dates of these nesting colonies range from 1980 to 2003 (WDFW, 2006). Bald eagle (*Haliaeetus leucocephalus*) nests have also been documented in Reaches 1A and 1C (WDFW, 2004). A seabird colony outside of the City's jurisdiction, associated with the northeast shore of Commencement Bay and the Hylebos Waterway, as well as breeding purple martins (*Progne subis*) south of the City, may utilize nearshore resources within Federal Way.

4.3 Land Use Patterns

The City of Federal Way is located in the southwestern corner of King County. Federal Way is highly developed and has a well-established pattern of land use. Approximately 4.5 miles of Puget Sound shoreline bound the City to the west, South 272nd Street to the north, the King/Pierce County line to the south, and Interstate-5 (I-5) to the east. The Cities of Kent and Des Moines borders Federal Way on the north, the Cities of Auburn, Algona, and Pacific to the east, and the Cities of Milton and Tacoma to the south as well as portions of unincorporated Pierce County. The City's nearshore shoreline jurisdiction is composed of a variety of natural and human-modified landscape features that include natural and modified beaches, concrete, wood and rock bulkheads, and roads. These features are illustrated by the air photo depicting current conditions on Figures 11-A through 11-C.

4.3.1 Existing Land Use

The nearshore shoreline of Federal Way is predominantly developed as single-family residential, interspersed with parks, open space, and multi-family developments. The City has a diversity of housing types. The nearshore shoreline areas are comprised of approximately 55 percent single-family development, 18 percent parks, 14 percent open space, 10 percent vacant land, and 2 percent multi-family development. Existing land use categories per marine shoreline reach are shown in Table 8. Existing land use categories are derived from King County Assessor codes, compiled by parcel. Road right-of-way areas in the reaches are not included.

4.3.2 Comprehensive Plan

According to the City of Federal Way Comprehensive Plan Map (2002), the City's shoreline jurisdiction is largely comprised of properties designated as low- to medium-density residential (1 to 4.5 dwelling units per acre). Parks, Open Space and Public Facilities/Utilities designations comprise the second largest portion of the shoreline. Small areas designated as commercial, office and multi-family comprise the remainder.

General goals and policies established in the City of Federal Way Comprehensive Plan (2002) relate to the preservation of existing residential neighborhood character, protection of environmental resources, and the promotion of economic development. The Comprehensive Plan seeks to balance these social, environmental, and economic goals through land use and zoning regulations, critical areas regulations using best available science, and development regulations. In relation to shorelines, the Comprehensive Plan seeks to preserve or develop shorelines and adjacent areas in a manner that assures a balance of shoreline uses with minimal adverse effect on the quality of life, water, and environment (City of Federal Way, 2002).

The City's existing Shoreline Master Program goals and policies are included as an element in the land use chapter of the City's current Comprehensive Plan. These goals and policies encourage water-oriented uses and existing residential uses in balance with protection of the Puget Sound shoreline's natural resources (City of Federal Way, 2002). This document also establishes shoreline environment designations as Natural, Conservancy, Rural, or Urban Environments, depending on the land use and intensity of development. In the coastal shoreline, the existing shoreline environment designations are shown on Figures 12-A through 12-C.

4.3.3 Zoning Designations

Zoning designations in the City of Federal Way generally follow land use designations as discussed above under Comprehensive Plan Designation. Within the City's nearshore shoreline jurisdiction, zoning is exclusively residential single-family (Figures 12-A through 12-C). These include residential 1 unit/ 7,200 square feet (RS 7.2), residential 1 unit/9,600 square feet (RS 9.6), residential 1 unit/15,000 square feet (RS 15.0), residential 1 unit/35,000 square feet (RS 35.0), and residential 1 unit/ 5 acres (SE).

Table 8. Land Use, Zoning, and Shoreline Environments

Shoreline Reach	Existing Land Use by Percent		Zoning by Percent		Existing Shoreline Designations
1A	Multi Family	1	Single Family	34	Urban
	Open Space	34	Single Family Low Density	63	Conservancy
	Park	7			Rural
	Right of Way	2			
	Single Family Residential	63			
	Vacant	16			
1B	Open Space	28	Single Family	26	Conservancy
	Park	8	Single Family Low Density	71	Rural
	Right of Way	96			Natural
	Single Family Residential	56			
	Utilities	1			
	Vacant	5			
1C	Multi Family	6	Single Family Low Density	99	Conservancy
	Open Space	2			Rural
	Park	38			
	Right of Way	1			
	Single Family Residential	45			
	Vacant	8			

4.3.4 Roads and Bridges

As described above the majority of the City's shoreline is occupied by low- to medium-density single-family development. Public shoreline access is available at Dash Point State Park, Dumas Bay Park, Dumas Bay Center, and Poverty Bay Park. Limited shoreline access and uniformity in

shoreline land use (single family) created a land use pattern with relatively few roads in the City's shoreline. Most of the roads that provide access to the shoreline are located outside the City's shoreline jurisdiction. The exceptions are a small portion of Southwest 300th Place in shoreline environmental Reach 1B, and Southwest 292nd Street, 2nd Avenue Southwest, and Southwest 291st Street, in Reach 1C. All streets in the City's shoreline are local streets.

However, one larger roadway influences the shoreline area by providing access, but is outside of the City's shoreline. Leading to Dumas Bay Center, Dumas Bay Park, and Dash Point State Park, is Southwest Dash Point Road, State Route 509 (located in Reach 1B, 1C). King County Metro, Sound Transit, and Pierce Transit provide transit services in the City of Federal Way. The only transit route in the Federal Way nearshore shoreline vicinity is Metro's Route 175 that provides service along Southwest Dash Point Road.

4.3.5 Wastewater and Stormwater Utilities

Lakehaven Utility District (District) provides sanitary sewer service within the City's boundaries and to unincorporated areas to the east and north of the City (including all PAA regions except a small area at the northeastern portion of the PAA area). The District operates and maintains 2 wastewater treatment facilities and a collection system consisting of 27 sewage pump stations, approximately 275 miles of sanitary sewer pipe, and 6,400 manholes. The District's area is divided into seven basins, the two largest of which (Redondo and Lakota) serve the majority of the City. Wastewater from the Redondo and Lakota Basins is treated by the District's two secondary wastewater treatment facilities, one of which is located near the Dumas Bay shoreline planning area. The five remaining basins are relatively small, serving areas around the perimeter of the two large basins on the south, north, and east. Wastewater from these basins is conveyed to other utilities for treatment. The potential impacts to shoreline areas associated with the above sanitary sewer systems are low. The Redondo treatment facility discharges approximately 1,030 feet offshore and has remained in compliance with previous permits.

The City of Federal Way's Comprehensive Plan was last updated in 2002. At the time of update, an estimated 7,500 on-site disposal systems were still in operation within the Lakehaven Utility District's corporate boundaries. The plan indicates that the District will integrate the remaining on-site disposal systems over time as they became unfeasible to maintain and/or require sewer connection for redevelopment. Recommendations within the plan include the expansion and upgrade of existing treatment and conveyance facilities, and installation of new conveyance facilities to provide service to areas in the City and PAA that are currently using on-site septic systems.

The City of Federal Way operates a stormwater management system. According to the City's Comprehensive Plan (2002), the City has completed projects to create regional detention and treatment facilities serving the City over the last decade. Localized stormwater treatment is also required for new developments. The 1994 Surface Water Facilities Plan (City of Federal Way, 1994) indicates that regional facilities have been designed with a 100-year flood storage capacity. All other stormwater system elements have been designed to a 25-year flood storage capacity. Chapter 16 of the Federal Way Municipal Code and the King County Surface Water Design Manual establishes stormwater standards for new development.

Undetained and untreated stormwater runoff can deliver pollutants to waterbodies, including heavy metals and other pollutants associated with automobiles and roadways. Water quality impairments described in previous sections include the presence of mercury and other metals in local streams, wetlands, and lakes. Untreated stormwater runoff discharging to surface water bodies is likely a contributing factor.

4.3.6 Other Utilities

According the City's Comprehensive Plan (2002) and the Lakehaven Utility District's Comprehensive Water System Plan (1994), the District maintains decentralized water supply production facilities that serve the majority of the City. The District operates 27 wells with the water system connected by interties to the water supply of other utility districts. The system allows the District to buy and sell water according to intra-District supply demands. Water systems attached to the District through interties include the Highline Water District, Tacoma Public Utilities, and the City of Milton's water supply system. These surrounding water supply systems and other neighboring water suppliers provide portions of the City's water supply. The City's PAA is partially within the District's water supply area and those of neighboring water suppliers. In addition, the City of Tacoma, Fruitland Water District, and several private landowners own production wells.

A variety of gas, telephone, electric, and related utilities serves the existing residential and commercial developments within the nearshore shoreline planning areas.

4.3.7 Existing and Potential Public Access Sites

Approximately 31 percent of the City's shoreline is dedicated as parks or open space and is available for public access and use. Figure 13 shows the locations of all the shoreline public parks and open space within the City's shoreline. Existing parks, open space, and public facilities in the City's shoreline planning area include the following:

- **Dash Point State Park** – This 398-acre state park is located on the westernmost point of the Federal Way marine shoreline. The park provides access to 3,302 feet of Puget Sound marine shoreline. The park also contains two covered picnic shelters, 11 miles of hiking and biking trails, amphitheater, and 138 camping sites, with a mix of primitive tent sites and a serviced campground.
- **Dumas Bay Park –** This 19.3-acre neighborhood park is located along the City's western Puget Sound shoreline, north of Dash Point State Park, off Dash Point Road. The park offers 12 parking stalls and unpaved trails, which lead to the beach front. The park also contains interpretive signs.
- **Dumas Bay Centre –** Located on the north side of Dumas Bay, opposite Dumas Bay Park, the Dumas Bay Center features the Knutzen Family Theater, a retreat and meeting center, as well as a park and Puget Sound beach front.
- **Poverty Bay Park** – Located north of Dumas Bay Center, this park is a 48-acre site of undeveloped open space, with approximately 500 feet of beach shoreline.

Opportunities for new access to the shoreline in Federal Way are limited. The City and state park resources and the public open space offer access to the shoreline and Puget Sound

throughout the City. Most other areas are developed residentially. The City could explore developing additional street-end overlooks or beach access points. Undeveloped rights-of-way total 1.7 acres in the nearshore shoreline environments; these could be potential beach access or overlooks.

4.3.8 Historical/Cultural Resources

The existing Federal Way Comprehensive Plan provides a general goal to identify, protect, and restore those areas and facilities within the City that are of historical or archeological significance (City of Federal Way, 2002). The plan establishes a goal to ensure that historic properties and archeological sites are protected as "important elements in the overall design of the City." Policies in the Comprehensive Plan define characteristics that enable the identification of historic and archeological sites, and direct the City to preserve and protect these sites from incompatible land uses.

Native American use of waterbodies throughout western Washington has been well documented. Native peoples undoubtedly used tributaries of the Green River, the Hylebos Creek, and Puget Sound Marine shoreline for fisheries resources. Historic (General Land Office) GLO survey maps from the 1860s do not identify any Native American village sites or any other Native American sites within the City's marine shoreline planning area. The Historical Society of Federal Way includes an article review of Native American use within the vicinity of the City. The article does not indicate that village sites are known to exist within the vicinity. However, the article notes the presence of Native American artifacts and, in one instance, human remains along the marine shoreline (Caster, 2005). Shell middens have been documented within the City's marine shorelines. The City requires review of archeological and historical resources on a parcel-by-parcel basis during development review as warranted.

The Historical Society of Federal Way works to restore and preserve structures and artifacts of historical significance within and around Federal Way. The society owns and maintains two historical cabins, both of which have been relocated to Historic Cabins Park near 348th Street and 4th Avenue South. The park area is not within the City's Shoreline Planning Area (Historical Society of Federal Way, 2003).

The Washington State Department of Archeology and Historic Preservation maintains a database of sites listed on Washington's Historic register and the national register. A search of the database for sites within the City's shoreline planning area revealed no listed sites of historical significance (DAHP). Additionally, no sites are listed on King County's Local Landmarks List (King County, 2006).

5.0 FRESHWATER LAKES PLANNING AREA INVENTORY

The purpose of this section of the report is to inventory and characterize freshwater lake conditions within the Shoreline Planning Areas in greater detail and in the context of the larger watershed. The intent is to identify how existing conditions in the freshwater lake shoreline influence or contribute to alterations of processes that maintain aquatic ecosystems. The study area is shown on Figure 1 and subsequent figures as the City's shoreline planning area.

5.1 Physical Features

5.1.1 Drainage Basins and Surface Water

Drainage in the Federal Way area is divided into five basins: Lower Puget Sound, Lower Green River, Mill Creek, Hybelos Creek, and White River Basins. Surface water that does not feed the freshwater lakes is directed either west to Puget Sound, east into the Duwamish-Green River Valley, or south to Commencement Bay. Freshwater lakes that are part of the shoreline jurisdiction are located in all the drainage basins and are discussed below.

Increased sedimentation in urban lakes is a common issue of concern. Particles can carry pollutants, metals and bacteria into lakes, which can affect productivity, habitat and recreational values. Federal Way has identified increased sedimentation as an issue of concern and has several programs in place to reduce its transport. Since there is limited data available on sediment loading, this issue is not described further.

Steel Lake

Steel Lake (Reach 2) is located in the Lower Puget Sound basin in the western part of Federal Way. Streams within the basin generally flow north and west into Puget Sound and have incised ravines into the steep coastal bluffs. Steel Lake is situated on top of low-permeability till, which suggests that it likely receives most of its water from surface runoff from the adjacent hills rather than from groundwater seepage. Although there is not any visible inflow, surface water in the watershed is conveyed to the lake and discharged through 14 stormwater outfalls. Outflow passes through a Category 1 wetland on the western shoreline and then flows through a culvert to another wetland and then becomes Redondo Creek, flowing through the City of Des Moines to the Puget Sound.

The City established the Steel Lake Management District (LMD) in 2003 to provide integrated aquatic vegetation management and community education. The LMD program, in effect for the past four years, continues ten years of active aquatic weed management in Steel Lake. This program has seen considerable success in the reduction of aquatic weeds and the maintenance of beneficial uses (i.e. swimming, fishing, boating).

Star Lake

Star Lake (Reach 3) is located in the Lower Green River basin in the Federal Way PAA. Topography in the basin directs surface water, including the outlet stream of Star Lake, eastward into the Duwamish-Green River Valley. Star Lake lies on till and recessional outwash deposits

that overlie till at a shallow depth. Star Lake is likely a kettle lake formed by the melting of large blocks of glacial ice buried in the glacial drift of outwash plains. Consequently, small streams, runoff and groundwater are the primary contributing water sources to the lake. The outfall is via a pipe and culvert to Bingham Creek and then to the Green River.

Lake Dolloff and Lake Geneva

Lake Dolloff (Reach 4) and Lake Geneva (Reach 5) are located in the Mill Creek basin in the Federal Way PAA. Surface drainage in the basin flows eastward into the Duwamish-Green River Valley through the Mill Creek valley of Auburn. Mill Creek, which drains the south end of Lake Dolloff, has incised a deep ravine that is also fed by small tributary streams, which drain the surrounding hillsides. Lake Dolloff is formed on recessional outwash deposits. Although there are no major inflows to the lake, wetland areas, runoff and groundwater are contributing water sources. An outflow through a wetland exists at the southern end of Lake Dolloff (Mill Creek).

Lake Geneva lies on top of till and receives inflow t from a small stream on the southern end of the lake, adjacent wetland areas, runoff and groundwater. Outflow exits at the northeast corner of Lake Geneva through a wetland, which forms a small tributary to Mill Creek.

North Lake and Lake Killarney

North Lake and Lake Killarney (Reaches 6 and 7) are located in the East Hylebos Creek Basin in the southeast part of Federal Way. Both lakes are tributary to East Hylebos Creek, which flows southward, combining with the mainstem of the West Hylebos, which flows into Commencement Bay. Other small streams in the basin also drain to the south and either join with East Hylebos Creek or terminate in wetland areas. Both lakes lie on top of till, and therefore likely receive surface runoff from the surrounding area.

North Lake is located in the East Hylebos Creek basin within the City limits for Federal Way. Inflow occurs via a small tributary through a wetland on the north shore. Groundwater, runoff and precipitation are additional water sources. North Lake drains to a pond on the Weyerhaueser campus then through a pipe to a wetland, which drains to the East Branch of the West Fork East Hylebos.

The northwestern section of Lake Killarney is located within Federal Way City limits, with the remainder of the lake within the PAA. There are no stream inflow sources. A wetland along the northern boundary likely serves as a water source during certain periods of the year, with groundwater, precipitation and runoff acting as the primary sources of incoming water. Outflow exits the lake to the southwest through a small, concrete culvert into a tributary. Lake Killarney drains to the mainstem East Hylebos Creek.

Five Mile Lake

Five Mile Lake (Reach 8) is situated in the White River drainage basin in the Federal Way PAA. The lake is fed by wetlands to the north as well as springs, runoff and groundwater. Five Mile Lake is likely a kettle lake formed by the melting of large blocks of glacial ice buried in the

glacial drift of outwash plains left behind as continental glaciers receded. Five Mile lake drains to Trout Lake to the southeast and then flows to the White River.

5.1.2 Geologic Hazard Areas

5.1.2.1 Seismic Hazard Areas

King County GIS maps (accessed on 5/18/06 at http://www.metrokc.gov/gis/mapportal/iMAP_main.htm) do not indicate seismic hazards associated with the freshwater lake areas (Reaches 2 through 8). Areas of low to moderate liquefaction susceptibility are designated on maps produced by the Washington Department of Natural Resources (Palmer et al., 2003); however, map coverage is limited to the western part of Federal Way, and does not include the freshwater lakes planning area.

Correlations between soil conditions and liquefaction susceptibility in the western part of Federal Way permit some inferences regarding the hazard in the unmapped areas of the freshwater lake planning area. Regions in the western part of Federal Way that are mapped as having low to moderate liquefaction susceptibility include the areas around Lorene and Jeane Lakes as well as several smaller lakes which are unnamed on existing maps. Typically, those areas considered to be susceptible to liquefaction are mapped as recessional outwash or consist stratigraphically of fine-grained wetland deposits overlying granular recessional outwash deposits. Those areas underlain by till are generally considered to have very low liquefaction susceptibility. The shorelines of Star, Dolloff, and Five Mile Lakes (Reaches 3, 4, and 8) are underlain largely by recessional outwash and/or wetland deposits, and thus most likely have low to moderate liquefaction susceptibility. The shorelines of Steel and North Lakes and Lakes Geneva and Killarney (Reaches 2, 6, 5 and 7) are underlain primarily by till, with small areas of wetland and outwash deposits. Most of the areas within these segments would likely have very low liquefaction susceptibility.

5.1.2.2 Erosion Hazard Areas

Erosion hazard areas are not present within the majority of the freshwater lakes shoreline segments (Reaches 2 through 8) according to City GIS maps and King County GIS maps (Figures 9D through 9H). An exception is the outlet located on the western shoreline of Steel Lake (Reach 2), which is mapped as an erosion hazard area. That outlet feeds a small stream, which flows westward to Puget Sound. Approximately 11 percent of the Steel Lake Reach is designated an erosion hazard area.

The drainage basins for six of the seven freshwater lakes in the shoreline planning area contain erosion hazard areas: Steel, Star, Dolloff, North Lakes and Lakes Geneva and Killarney. Those areas with erosion hazards are primarily concentrated in narrow corridors along streams or on hillsides, and make up a very small proportion of the drainage basin analysis area.

5.1.2.3 Landslide Hazard Areas and Steep Slopes

Landslide hazard areas and steep slopes do not occur within the fresh water lakes shoreline reaches (Reaches 2 through 8) according to City GIS maps and King County GIS maps (Figures 9D through 9H). However, landslide hazards are in fact present in the far eastern portions of the

shoreline analysis areas for Five Mile Lake, Lake Geneva, and Star Lake. Those areas include the relatively steep valley walls of the Duwamish-Green River Valleys and the ravines of several small streams, including Mill Creek.

5.1.3 Aquifer Recharge Areas

Critical aquifer recharge areas in Federal Way, as defined above in section 4.1.3, are commonly associated with regions that are underlain by recessional outwash deposits. Such deposits generally have high infiltration rates because they tend to be relatively permeable and allow for rapid movement of water. Alternatively, infiltration rates in till are typically low because of limited pore space arising from a variety of grain sizes and a high degree of compaction.

Critical aquifer recharge areas in the freshwater lakes planning area include the areas around Star, Dolloff, and Five Mile Lakes (Reaches 3, 4, and 8) according to City GIS maps and King County GIS maps (accessed on 5/22/06 at http://www.metrokc.gov/gis/mapportal/iMAP_main.htm).

The City has mapped wellhead protection zones within the city limits and the PAA. The majority of the wellhead protection areas do not coincide with the shoreline reaches, however are mapped adjacent to the east side of North Lake and adjacent to the east side of Lake Killarney, extending to Lake Geneva. These areas are managed as Wellhead Protection Areas (*Federal Way City Code* (FWCC), Chapter 22).

5.1.4 Flood Hazard Areas

Frequently flooded areas are defined in Chapter 18-28 of the FWMC as those areas in the floodplain subject to a one percent or greater chance of flooding in any given year including but not limited to such areas as streams, lakes, coastal areas and wetlands. According to King County GIS maps (Figure 6), the shoreline of Lake Dolloff (Reach 4) is located within a 100-year floodplain, and thus may be considered a flood hazard area. The remaining areas located within the freshwater lakes shoreline jurisdiction (Reaches 2, 3, 5, 6, 7, and 8) are not currently considered to be within 100-year floodplains.

5.1.5 Streams

The upper plateau lies within 5 drainage basins that have been identified in Federal Way: the Lower Green River, Mill Creek, Hylebos Creek, White River and Lower Puget Sound. Of these, the Hylebos Creek and White River are within Watershed Resource Inventory Area (WRIA) 10 – Puyallup/White; the other drainage basins, including the portion of the Lower Puget Sound basin, which covers the Redondo Subarea, are within WRIA 9 – Duwamish/Green. The freshwater shoreline lakes form the headwaters for several streams including Redondo Creek, tributaries to Mill Creek, and the East and West Branches of Hylebos Creek

The Hylebos Creek is the largest drainage basin for the upper plateau of Federal Way. The Hylebos Creek basin is approximately 18,361 acres in size, and contains 25 miles of stream, 11 named lakes, and 250 acres of wetlands (Kerwin, 1999). There are two major tributaries to Hylebos Creek, the West and East Branches. The headwaters of the West Hylebos Creek are located in Federal Way near South 320th Street (Pierce County, 2006). The East Branch

originates in King County near North Lake and Lake Killarney in the City's PAA. The two branches join east of Interstate-5 in the City of Milton. From the confluence of these branches in Milton, the Hylebos Creek downstream is considered a shoreline of the state. Hylebos Creek enters the Hylebos Waterway in Tacoma and drains to Puget Sound's Commencement Bay.

The majority of the Hylebos basin is urbanized, and covered by commercial development and single and multifamily residential dwellings. Approximately two-thirds of the basin is located in the city of Federal Way, which experienced large population growth in the 1980's (Friends of the Hylebos Wetlands, 2006). As of 1999, the City of Federal Way was 96 percent built out, with more than half the land area covered with impervious surfaces (Kerwin, 1999). Due to deforestation, the increase in impervious surfaces, and the loss of adjacent wetlands in the Hylebos Creek basin, the damaging peak flows in the creek have increased dramatically, as compared to pre-development conditions. .

There has not been a comprehensive water quality study performed on the Hylebos basin. What is the source of this information? However, it is generally accepted that non-point and point source pollution problems affect water quality throughout the basin (Kerwin, 1999).

5.1.6 Shoreline Modifications

Land use and development surrounding the freshwater lakes in Federal Way have resulted in shoreline modifications including the placement of bulkheads, removal of forested vegetation and other alterations as described below. Shoreline modifications provided here are based upon King County's method of assessing shoreline modifications. From aerial photographs, the number of docks in each of the lakes was tallied. It was then assumed that if a dock was present, then the shoreline was modified (one to one relationship). The following table (Table 9) summarizes this information:

Table 9. Shoreline Modifications by Lake

Shoreline Reach	Number of docks	Number of properties	% Shoreline modified
Steel Lake	60	101	60
Star Lake	52	87	60
Lake Dolloff	0	73	0
Lake Geneva	17	66	26
North Lake	33	75	44
Lake Killarney	37	84	44
Five Mile Lake	25	46	54

Source: based on interpretation of 2002 aerial photographs.

In addition, a one-day, informal, field reconnaissance of the lakes was completed to provide a generalized description of the shoreline. Detailed information on shoreline modifications for individual lakes is unavailable.

Steel Lake

The basin around Steel Lake was already significantly developed in 1976 when only 15 percent of the land in the drainage basin was classified as forested or unproductive (USGS, 1976). According to King County, in 2002 less than 10 percent was classified as forested or timber harvest areas (King County, 2002) indicating rapid urbanization.

From the field reconnaissance, it appeared that most residential parcels on the lake have been developed. The exceptions are the park, and wetlands and the few remaining undeveloped lots. Of the developed parcels, at least 60 percent have modified shorelines.. Extensive shoreline armoring and overwater structures have significantly reduced the riparian vegetation on Steel Lake, although abundant riparian vegetation has been observed near the creek inlet at the west side of the lake. Low-growing vegetation and shrubs in the nearshore are lacking, however numerous mature trees still are present in most of the developed parcels. The wetland to the west covers approximately 10 percent of the shoreline and provides good riparian conditions and habitat.

Star Lake

Land use surrounding Star Lake has changed since 1976 when 46 percent of the land in the drainage basin was still classified as forested or unproductive (USGS, 1976). According to King County, in 2002 less than 10 percent was classified as forested or cleared (King County, 2002). The shoreline of Star Lake is entirely developed with multiple layers or tiers of houses as one moves up the slope away from the lake.

From the field reconnaissance, it appeared that nearly every available parcel on the lake has been developed. Of the developed parcels, approximately 60 percent have modified shorelines. Significant riparian and upland vegetation are lacking. There are relatively few large trees within 25 feet of the shoreline although there are occasionally over hanging willows and other shrubs near the shore.

Lake Dolloff

Land use surrounding Lake Dolloff has changed since 1976 when 65 percent of the land in the drainage basin was still classified as forested or unproductive (USGS, 1976). According to King County, in 2002 only 25 percent of the land in the drainage basin was still classified as forested or cleared (King County, 2002).

From the field reconnaissance, it appeared that about two-thirds of the available parcels on the lake have been developed; however most houses have small footprints and are placed further away from the lakeshore. Very few bulkheads are visible, allowing for intact riparian buffer zones near the waters edge along most of the shoreline. Multiple layers of vegetation are present, consisting of over-hanging trees, shrubs, and large evergreens in many cases within 25 feet of the shoreline. This provides excellent coverage and habitat. Large wetland areas exist in the north

and south ends of the lake as well as a small section on the eastern shore. Combined, these wetlands cover approximately 30 percent of the lakeshore and provide good riparian conditions and habitat.

Lake Geneva

Approximately 28 percent of the land in the drainage basin surrounding Lake Geneva was still classified as forested or unproductive in 1976 (USGS, 1976). According to King County, in 2002 approximately 8 percent was still classified as forested or cleared (King County, 2002).

From the field reconnaissance, it appeared that a majority of the available parcels on the lake have been developed. However, the use of bulkheads seemed to be minimal (26%, according to King County's method). Compared to most urban lakes, nearshore vegetation was relatively intact throughout most of the lake shoreline and consisted of over hanging trees and shrubs. The eastern shoreline had an approximately 1,000 foot-long section of steep shoreline containing a mature stand of trees. A wetland area in the northern section of the lake provides additional shoreline protection and habitat for a variety of species. This wetland comprises approximately 5 percent of the lakeshore.

North Lake

In 1976, approximately 73 percent of the land in the drainage basin was still classified as forested or unproductive (USGS, 1976). According to King County, in 2002 approximately 48 percent was still classified as forested or cleared (King County, 2002).

From the field reconnaissance, only a little over half of the lake appeared to be developed. Weyerhaeuser owns a 52-acre parcel of land that protects most of the western shoreline. Of the developed area, bulkheads comprised approximately 44% percent of the shoreline. Some overhanging trees and shrubs were present along segments of the developed shoreline, but most mature trees were absent within 25 feet of the lake. The second-growth forest along the western shoreline does provide a diverse, complex, and near natural riparian zone. In addition, the smaller wetlands at the inflow/outflow provide additional habitat.

Lake Killarney

Approximately 59 percent of the land in the Lake Killarney drainage basin was still classified as forested or unproductive in 1976 (USGS, 1976). According to King County, in 2002 approximately 17 percent was still classified as forested or cleared (King County, 2002).

From the field reconnaissance, the use of bulkheads seemed to be minimal especially in the North arm where nearshore vegetation was predominately intact providing in-water structure. The eastern shoreline was moderately steep, however development was not tiered; thus many mature trees were still present. In the southern arm, more of the developed parcels exhibit featureless shorelines with little habitat. According to King County's method, 44% of the shoreline is modified. A wetland area in the northern section of the lake comprising approximately 10 percent of the lakeshore provides additional protection and habitat. In addition, a 10.8-acre parcel of land used as a park on the western shoreline contains diverse vegetation and natural shoreline.

Five Mile Lake

Land use has changed since 1976 when 75 percent of the land in the drainage basin was still classified as forested or unproductive (USGS, 1976). According to King County, in 2002 approximately 42 percent was still classified as forested or cleared (King County, 2002).

From the field reconnaissance, only about half of the available parcels on the lake appear to have been developed. However, of these, approximately 54% percent have bulkheads and the featureless shoreline habitat that is associated with them. In-water, nearshore vegetation consists of periodic stands of cattail. There are relatively few large trees within 25 feet of the shoreline although there are occasionally over-hanging willows and other shrubs near the shore. An exception is at Five Mile Park, where a 600-foot section of shoreline contains a stand of mature trees. The large wetland areas in the north and northeastern sections of the lake that have protected shorelines provide good riparian conditions and habitat. These wetlands comprise approximately 35 percent of the lakeshore.

5.2 Biological Resources

5.2.1 Shoreline Plant Habitat

Shoreline plant habitats include the areas where plants grow along the edges of the lakes as well as the littoral zone where plants grow where they still receive light. The shallow shoreline of several of the lakes in Federal Way offer excellent habitat for aquatic plants. In addition, several lakes still contain sections of intact riparian zones and vegetative buffers that also provide habitat for native plants. However, non-native invasive aquatic plants also take advantage of these shoreline habitats, which can lead to a loss in biological diversity. The following summary provides information on non-native invasive aquatic plant infestations in the Federal Way lakes:

Steel Lake – Eurasian watermilfoil *(Myriophyllum spicatum)*; fragrant water lily *(Nymphaea odorata)*; yellow flag iris *(Iris pseudacorus)* purple loosestrife *(Lythrum salicaria).* Management activities include herbicide applications and handpulling.

Star Lake – Eurasian watermilfoil *(Myriophyllum spicatum).* Management activities include herbicide treatments.

Lake Dolloff - Eurasian watermilfoil *(Myriophyllum spicatum)*; fragrant water lily *(Nymphaea odorata)*; Brazilian elodea *(Egeria densa).* Management activities have included applying herbicides to control Eurasian watermilfoil and eradicate Brazilian elodea.

Lake Geneva - fragrant water lily *(Nymphaea odorata);* Eurasian watermilfoil *(Myriophyllum spicatum).* Water lilies have been brought under control through previous treatment efforts. Current activities are underway for the control of Eurasian watermilfoil through handpulling.

North Lake - Eurasian watermilfoil *(Myriophyllum spicatum)*; fragrant water lily *(Nymphaea odorata)*; yellow flag iris *(Iris pseudacorus)*; purple loosestrife *(Lythrum salicaria).* Management activities include herbicide applications and handpulling for removing all four species.

Lake Killarney - Eurasian watermilfoil *(Myriophyllum spicatum)*; fragrant water lily *(Nymphaea odorata)*; yellow flag iris *(Iris pseudacorus)*; purple loosestrife *(Lythrum salicaria).* Successful herbicide treatments have resulted in controlling Eurasian watermilfoil and the fragrant water lilies.

Five Mile Lake – None documented to date.

5.2.2 Wetlands

Lacustrine and palustrine wetlands are identified by the NWI immediately adjacent to and associated with lakes within the City's shoreline planning area. In addition, the City's Wetland Inventory (Sheldon and Associates, 1999) identifies and maps wetlands throughout the City, along with classification pursuant to FWMC 18-28. These inventories are used as primary sources in the discussion of wetlands within the planning area of seven freshwater lakes included in the City's shoreline jurisdiction (Figures 6 and 11-D through 11-H).

Except for Steel Lake (Shoreline Reach 2), most of the freshwater lakes within the City are considered wetlands by the City's Wetland Inventory. However, in many cases the lakes constitute deepwater habitats (water depths greater than 6.6 feet) that are not wetland according to the state definition. The Category I (FWCC 18-28) wetland identification of these lakes (Shoreline Reaches 3 – 8) includes open water areas and shoreline edges, as well as (with the exception of Star Lake, Reach 3) portions of the land immediately adjacent to the lakes. At Steel Lake, a large, Category I wetland was identified beginning at the western-most portion of the lake and continuing northwest across South 304th Street through the undeveloped area. Three other small, Category III wetlands were identified along the north (2 wetlands) and south (1 wetland) shores of Steel Lake (Figure 11-E).

The NWI maps identified all of the seven freshwater lakes (Reaches 2 – 8) as permanent lacustrine wetlands, with a pattern of similar ecological system classification at all lakes except Star Lake. The entire area of Star Lake was classified as a lacustrine open water wetland with no other wetlands identified in the adjacent areas. Aquatic bed wetlands are mapped at or near each lake's shoreline.

Palustrine, or freshwater, wetlands were identified by the NWI map as adjacent and associated with all lake reaches except for Star Lake and Lake Geneva (Reaches 3 and 5). At Steel Lake (Reach 2), a scrub-shrub and forested wetland stretches from the west end of the lake to the northwest at the outlet stream. This wetland is considered an "associated wetland" and part of the shoreline jurisdiction. At Lake Dolloff (Reach 4), a palustrine forested wetland and open water/aquatic bed are mapped at the northwest end of the lake (Figure 11-E). This is considered "associated wetland" as is wetland areas to the northeast of Lake Dolloff and south of South 303rd Street. A wetland also extends along the outlet stream to the southeast.

At North Lake (Reach 6), a palustrine scrub/shrub and emergent wetland is identified as extending to the north from the northeast corner of the lake (Figure 11-F). At Lake Killarney (Reach 7), a palustrine emergent and scrub-shrub wetlands are mapped as adjoining to the north of the lake (Figure 11-G). At Five Mile Lake (Reach 8), forested, scrub-shrub, and open water

wetlands are identified extending the north from the north end of the lake and spreading out to the north and east from the northeast corner of the lake (Figure 11-H).

5.2.3 Critical Wildlife Habitat and Species

Critical fish and wildlife habitat areas are those areas identified as being of critical importance in the maintenance and preservation of fish, wildlife, and natural vegetation. Critical habitat, or fish and wildlife habitat conservation areas, means habitat areas with which endangered, threatened, or sensitive species of plants or wildlife have a primary association (e.g., feeding, breeding, rearing of young, migrating) (Chapter 18-28 FWCC). Fish and wildlife habitat conservation areas in the fresh waters of Federal Way include streams; ponds under 20 acres; lakes, ponds and streams planted with game fish by a governmental or tribal entity; and State natural area preserves and natural resource conservation areas.

Several state and federally listed species are known to occur or could potentially occur within the City's freshwater shoreline planning area, as well as within waters downstream of Federal Way (Table 10; Figure 10). Federally listed species that have been documented in the City include bald eagle (*Haliaeetus leucocephalus*), common loon (*Gavia immer*), and Puget Sound/Strait of Georgia coho salmon (*Oncorhynchus kisutch*), a federal species of concern. In general, coho and other anadromous salmonids are not found within the freshwater lakes of Federal Way and its PAA; however, salmonids do inhabit streams down gradient of these lakes. Wildlife usage of each freshwater lake is detailed below.

Table 10. Federal and State Listed Threatened and Endangered Species in Federal Way.

Common name	Scientific name	Status	Within Federal Way or PAA?	Downstream from Federal Way?
Bald eagle	*Haliaeetus leucocephalus*	Threatened	Yes	Yes
Common loon	*Gavia immer*	State Sensitive	Yes	No
Pileated woodpecker	*Dryocopus pileatus*	State Candidate	No	Yes
Puget Sound/ Strait of Georgia coho salmon	*Oncorhynchus kisutch*	Federal species of concern	Yes	Yes
Puget Sound Chinook salmon	*Oncorhynchus tshawytscha*	Threatened	No	Yes
Puget Sound steelhead	*Oncorhynchus mykiss*	Proposed threatened	No	Yes
Coastal/Puget Sound bull trout	*Salvelinus confluentus*	Threatened	No	Yes

Steel Lake

Steel Lake is within the Lower Puget Sound drainage basin, drains to the Puget Sound through Redondo Creek. The lake supports stocked trout, largemouth bass, and yellow perch (King County, 2005 and WDFW 2006). Streams within this basin are known to provide habitat for coho and fall chum salmon (WDFW, 2006).

Star Lake

Star Lake is within the Lower Green River Drainage Basin. The lake supports stocked trout, bass, and various warm-water species (King County, 2005 and WDFW 2006). The Lower Green River basin has rearing habitat for fall chinook, fall chum, and summer steelhead; spawning and rearing habitat for coho; and documented presence of pink and sockeye salmon, bull trout/dolly varden, and winter steelhead (WDFW, 2006). A pileated woodpecker nest has been identified approximately 0.6 miles away, and bald eagle nest has been identified slightly over one mile from Star Lake (WDFW, 2004).

Lake Dolloff and Lake Geneva

Lake Dolloff and Lake Geneva are within the Mill Creek drainage basin. Lake Geneva supports populations of stocked trout and largemouth bass (King County, 2005 and WDFW 2006). An adult common loon has also been documented at Lake Geneva (WDFW, 2004). Lake Dolloff also supports populations of stocked trout, largemouth bass, yellow perch and brown bullhead catfish as well as other fish species (King County, 2002 and WDFW 2006). Mill Creek is known to provide habitat to fall chinook and winter steelhead, as well as spawning and rearing habitat for coho salmon (WDFW, 2006). Coho, chum and winter steelhead have been observed spawning in Mill Creek (Kerwin and Nelson, 2000). Juvenile coho, chum, winter steelhead, cutthroat and chinook have been captured in the creek.

North Lake and Lake Killarney

North Lake and Lake Killarney are within the Hylebos Creek drainage Basin. Both lakes support populations of stocked trout, and largemouth bass (WDFW 2006). Lake Killarney also supports other fish species including yellow perch, pumpkinseed sunfish, and brown bullhead catfish (King County, 2005 and WDFW 2006). Salmonids inhabiting East Hylebos Creek, which is fed by both North Lake and Lake Killarney, include coho salmon, chum salmon, and cutthroat trout (Taylor Associates, 2002). A bald eagle nest has been identified within one-quarter mile of North Lake (WDFW, 2004).

Five Mile Lake

Five Mile Lake is within the White River Drainage Basin. The lake supports populations of stocked trout (some years) and largemouth bass (King County, 2005 and WDFW 2006). There is no surface water connection from Five Mile Lake to the White River. The White River subbasin provides spawning or rearing habitat for fall and spring chinook, pink, fall chum, and coho salmon in addition to bull trout/dolly varden, winter steelhead, and cutthroat trout. Sockeye salmon adults are observed almost annually in this subbasin but there is some question to their ability to be naturally sustaining (Kerwin, 1999; WDFW, 2006).

5.2.4 Instream and Riparian Habitats

Streams and riparian corridors provide valuable wildlife habitat, a source of fluvial sediments to the marine shoreline, recreational opportunities, and support for a range of fish species. Five drainage basins have been identified in Federal Way that affect shorelines: Lower Green River, Mill Creek, White River, Hylebos Creek, and Lower Puget Sound. Of these, the Hylebos Creek

and White River are within Watershed Resource Inventory Area (WRIA) 10 – Puyallup/White; the other drainage basins, including the portion of the Lower Puget Sound basin, which covers the Redondo Subarea, are within WRIA 9 – Duwamish/Green.

Information on riparian habitat conditions was drawn in particular from the following documents: *Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (Water Resource Inventory Area 9 and Vashon Island)* (King County, 2000); *A Catalog of Washington Streams and Salmon Utilization - Volume I, Puget Sound Region* (Williams et al. 1975), and *Federal Way Potential Annexation Area Inventory* (Federal Way, 2002). The following characterization is focused on conditions relative to fish and wildlife habitat.

5.2.4.1 Lower Green River Drainage Basin

Approximately 18 percent of the riparian zone in the Lower Green River sub-watershed supports native deciduous trees. However, deciduous stands are usually narrow (<100 feet) or comprised of small, sparse trees mixed with patches of grass, pavement, or bare ground. Almost 50 percent of the riparian zone is comprised grass or shrubs, many of which are non-native. Over 80 percent of the riparian zone is currently considered to provide poor shade, organic matter recruitment, and sediment filtration because native vegetation communities have largely been converted to grass or shrubs and because development often extends to within 75 feet of the channel (King County, 2000). The lower Green River is on Ecology's 2004, 303(d) list for fecal coliform.

Star Lake, located in the Lower Green River Basin, is surrounded by residential land use. Significant riparian and upland vegetation is lacking. The riparian zone is largely vegetated with pasture grass (lawn) and ornamental tree species.

5.2.4.2 Mill Creek Drainage Basin

The Washington State Department of Ecology's (Ecology) Aquatic Use Category sets criterion for the protection of spawning, core rearing, and migration of salmon and trout, and other associated aquatic life. Mill (Hill) Creek has been categorized as Non-Core Salmon/Trout aquatic use. The creek is on Ecology's 2004, 303(d) list for temperature, dissolved oxygen, and fecal coliform bacteria.

Dolloff Lake and Lake Geneva are located within the Mill Creek Drainage Basin. Residential land use surrounds Lake Dolloff. Riparian vegetation appears to be somewhat intact at the north end of the lake, but at the south end, lawns and ornamental trees and shrubs dominate the riparian zone.

Lake Geneva also has significant residential land use on its shoreline. However, compared to most urban lakes, nearshore vegetation was relatively intact throughout most of the lake shoreline and consisted of over hanging trees and shrubs. Mature trees also occur in areas.

5.2.4.3 White River Drainage Basin

The White/Stuck River is channelized between levees along both banks from its confluence with the Puyallup upstream to RM 8.5. Water quality in the basin is generally good to excellent, but

some parameters have exceeded water quality standards because of sanitary sewage effluent form the cities of Buckley and Enumclaw. Mud mountain dam at RM 29.6 interrupts recruitment of LWD and gravel to the lower reaches of the White River. Riparian condition is affected by land use in the basin, which is predominantly mixed commercial/residential below RM 8 (Kerwin, 1999). The lower White River is on the 2004, 303(d) list for temperature and pH.

Five Mile Lake is both located within the White River Drainage Basin. There are patchy areas of intact riparian vegetation, particularly along the north shore near the Buddhist Center and Lakeview Christian Conference Center. There are relatively few large trees near the shoreline although there are occasional willows and other shrubs near the shore. An exception is at Five Mile Park, where a 600-foot section of shoreline contains a stand of mature trees.

5.2.4.4 Hylebos Creek Drainage Basin

The Hylebos Creek drainage basin is located primarily in southwest King County and includes the East Hylebos Creek (tributary 0006) and its three major tributaries (0016A, 0016, 0015). Habitat within the Hylebos Creek subbasin has been severely altered from its historical natural state. Residential development, erosion and frequent flooding threaten the creek. Portions of this subbasin have been channelized with an associated loss of riparian habitat (Kerwin, 1999).

In the upper portion of the basin, one tributary drains from Lake Killarney over a relatively flat upland till surface, south to 28th Avenue South and South 360th, then continuing to just south of Kits Corner Road to join East Branch of Hylebos. East branch Hylebos Creek flows from North Lake, then south through the Parkway Subarea ranging between 21st Place South and 25th Place South. The tributaries combine south of SR 161 and flow through a long, steep gradient reach over Vashon advance outwash. The East and West Branches of Hylebos Creek converge within the broad floodplain of Lower Hylebos Creek near the King-Pierce County line to form the mainstem (Taylor Associates, 2002). East Hylebos Creek habitat was surveyed in 2001 from RM 5.3 to RM 6.4. In this reach, habitat was predominantly low-gradient riffle stream habitat. The mean width of the wetted channel was 10 feet and the mean bankfull width was 30 feet. The mean maximum depth of all pools was 1.4 feet. The stream had 63 pools per mile, though there were no large pools (i.e., greater than one meter in depth), and no high-quality pools observed. LWD recruitment was good, as the native riparian buffer was wide and dense, composed of medium sized (12-20 inch diameter) hardwoods, with approximately 20 percent of the trees being mature conifers (Taylor Associates, 2002).

Both the East and West tributaries of the Hylebos Creek are perennial streams. Salmonids inhabiting each tributary of Hylebos Creek include coho salmon, chum salmon, and cutthroat trout (there are Chinook in West Branch Hylebos Creek). The stream appears to contain good salmonid habitat but the indicators in the pathway for watershed conditions are not properly functioning due to urbanization in the watershed (Taylor Associates, 2002). Lake Killarney has patches of riparian vegetation surrounding the lake. Most of the western riparian shoreline of North Lake is currently open space. The east shore of North Lake is entirely residential, and has essentially no native riparian vegetation. In contrast, open space and the Weyerhauser industrial and office park dominates the west shore of the lake, with healthy intact riparian vegetation overhanging the shoreline.

5.2.5 Water Quality

In order to classify the water quality of lakes, an assessment of the biological activity in each lake is made. This assessment (i.e. trophic state) is determined by a combination of three indicators namely: 1) clarity (Secchi depth), 2) nutrient levels (total phosphorus) and 3)algae levels (chlorophyll concentrations). Trophic state results are used to classify lake water quality into three categories: oligotrophic (refers to lakes of low productivity), mesotrophic (moderately productive), and eutrophic (highly productive). Although lake productivity is essential to life in a lake, high productivity can be considered undesirable due to the potential for increased algae growth. Rapid changes in in a lake's trophic state may also provide an indication of effects resulting from human-induced activities. Volunteers that were trained in water quality testing procedures obtained information provided here.

Another aspect of water quality relates to turbidity and suspended sediment. The Surface Water Management (SWM) Division has identified sedimentation and stormwater runoff in the lakes as an issue of concern. SWM currently has several programs in place to reduce the transport of sediments and other pollutants to lakes and streams. These programs include street sweeping, catch basin sediment level monitoring and cleaning, erosion/sedimentation control construction inspections and stormwater facilty improvements in the form of pollution control structures and regional detention facilities.

Lake size and depth as well as inflows and outflows all influence how a lake functions. There are other factors that contribute to the water quality of a lake, including residence time and the quality of the water entering a lake, however this information is not readily available.

Water quality information can also be obtained from Ecology's 303(d) list of waterbodies where tested pollutants exceed thresholds established by the state surface water quality standards. However, Steel, Star, Dolloff, Geneva, Killarney and Five Mile Lakes are listed erroneously on the 2004, 303(d) list. A reassessment of the data in January 2006 revealed that only two data points were submitted, meaning that they should be category 2 waters (due to lack of data). Since EPA had approved the list before Ecology noted the error, the listings could not be withdrawn. Therefore, data from Ecology's 303(d) list was not included in this assessment.

Steel Lake

Steel Lake does not have a visible inflow, but it does have an outflow on the western shoreline. The lake is 46 acres in size and is situated in a 254-acre watershed. The mean depth of the lake is 13 feet with a maximum depth of 24 feet.

Steel Lake can be classified as mesotrophic, indicating moderate productivity with very good water quality (King County, 2006). Water clarity is in the mid-upper range of the small lakes monitored in King County. In 2002 and 2004, the lake was treated for Eurasian watermilfoil (*Myriophyllum spicatum)*. Other state-listed noxious weeds at Steel Lake include fragrant water lily (*Nymphaea odorata*) and yellow flag iris *(Iris pseudacorus)* andpurple loosestrife *(Lythrum salicaria).* The Steel Lake Management District was created in 2003 for the purpose of managing aquatic vegetation and maintaining beneficial uses of the lake.

Star Lake

Star Lake does not have a visible inflow, but the outflow discharges to Bingham Creek via a culvert. The lake is 34 acres in size and is situated in a 376-acre watershed. The mean depth of the lake is 25 feet with a maximum depth of 50 feet.

According to data collected by volunteers trained by King County, Star Lake can be classified as oligotrophic, indicating low productivity with excellent water quality (King County, 2006). Water clarity is in the upper range of the small lakes monitored in King County. Eurasian watermilfoil *(Myriophyllum spicatum)* has been found in Star Lake.

Lake Dolloff

Lake Dolloff does not have a visible inflow, but does have an outflow through Mill Creek in the south end. The lake is 21 acres in size and is situated in a 518-acre watershed. The mean depth is 10 feet with a maximum depth of 19 feet.

Data collected by volunteers (trained by King County) from 1996-2000 classified Lake Dolloff as eutrophic, indicating it had high productivity with fair water quality (King County, 2002). Eurasian watermilfoil *(Myriophyllum spicatum)*, fragrant water lily *(Nymphaea odorata)*, and Brazilian elodea *(Egeria densa)* have been found in the lake. The King County Noxious Weed Program is conducting ongoing monitoring and treatment at this lake to attempt control of Brazilian elodea (Burke, 2007). Treatment included installation of aquatic weed fabric around the boat launch area in 2004, and intermittent monitoring and hand pulling of the weed since that time.

Lake Geneva

Lake Geneva does not have a visible inflow, but does have an outflow at the northeast corner. The lake is 29 acres in size and is situated in an 198 acre watershed. The mean depth is 19 feet with a maximum depth of 46 feet.

According to data collected by volunteers trained by King County, Lake Geneva can be classified as being borderline mesotrophic indicating it has low to moderate productivity and good water quality (King County, 2006). Water clarity is high and is in the upper range for the small lakes in King County monitored in 2004. Fragrant water lily *(Nymphaea odorata)* and Eurasian watermilfoil *(Myriophyllum spicatum)* have been found in Lake Geneva. The surrounding community has made efforts to control both of these invasive weeds in recent years, with efforts focused on hand pulling and removal (Burke, 2007). Additionally, floating islands of sediment have recently become an issue in the lake.

North Lake

North Lake has a small inflow via a tributary on the north shore and an outflow via a tributary in the southwest corner. The lake is 55 acres in size and is situated in a 425-acre watershed. The mean depth is 14 feet with a maximum depth of 34 feet.

North Lake can be classified as being mesotrophic, according to data collected by volunteers trained by King County, indicating moderate productivity and good water quality (King County, 2006). Water clarity is also good. Eurasian watermilfoil *(Myriophyllum spicatum)*, fragrant water lily *(Nymphaea odorata)*, yellow flag iris *(Iris pseudacorus)*, and purple loosestrife *(Lythrum salicaria)* have all been found at North Lake.

Lake Killarney

Lake Killarney does not have a visible inflow, but does have an outflow in the southwest corner. The lake is 31 acres in size and is situated in a 185-acre watershed. The mean depth is 9 feet with a maximum depth of 15 feet.

Lake Killarney can be classified as being borderline eutrophic, according to data collected by volunteers trained by King County, indicating moderately-high productivity and good water quality (King County, 2006). Water clarity is low due to the naturally high color resulting from the wetland along the northern shoreline. Eurasian watermilfoil *(Myriophyllum spicatum)*, fragrant water lily *(Nymphaea odorata)*, yellow flag iris *(Iris pseudacorus)*, and purple loosestrife *(Lythrum salicaria)* have been found at the lake. In addition, the community has supported copper sulfate treatment to kill nuisance phytoplankton populations.

Five Mile Lake

Five Mile Lake is fed by wetlands to the north and has an outflow in the southeast corner. The lake is 38 acres in size and is situated in a 593-acre watershed. The mean depth is 18 feet with a maximum depth of 32 feet.

According to data collected by volunteers trained by King County, Five Mile Lake can be classified as mesotrophic, indicating it is only moderately productive with generally good water quality (King County, 2006). However, water clarity has been historically low, due to the high dissolved oxygen content, and is rated as the third lowest of the small lakes monitored in King County. There are no documented observances of invasive aquatic species in Five Mile Lake.

5.3 Land Use Patterns

Land use patterns are described in the context of existing land use, as well as planned or future land uses that are established by Comprehensive Plan land use designations and zoning designations.

5.3.1 Existing Land Use

Existing land use is illustrated by the air photo depicting current conditions on Figures 11-D through 11-H. Existing land use was quantified using King County Assessor data. Existing or current use categories for each parcel were regrouped into generalized existing land use categories that correspond to the future land use categories used in the City's Comprehensive Plan. Additional categories of existing land use that do not have a corresponding Comprehensive Plan land use designation are vacant, agriculture, and unknown. Table 11 summarizes the existing land uses for each of the freshwater lake reaches below.

Table 11. Existing Land Use (by % Cover)

Shoreline Reach	Single Family	Multi Family	Office Industrial	Religious Services	Right-of-Way	Open Space Park	Vacant	Other
Steel Lake (Reach 2)	67.3	5.4			4.8	9.7	12.7	0.1
Star Lake (Reach 3)	80				6.5	4.7	2.1	6.7
Lake Dolloff (Reach 4)	60.2				8.2		29.8	1.8
Lake Geneva (Reach 5)	58.3				3.6	16.1	20.1	1.9
North Lake (Reach 6)	34.7		20.9		3.1	14.4	21.2	5.7
Killarney Lake (Reach 7)	53.8		21.6		0.1	11.6	12.1	0.8
Five Mile Lake (Reach 8)	32.06			5.8	11.5	39.09	9.1	2.45

5.3.2 Comprehensive Plan

According to the City of Federal Way Comprehensive Plan Map (2006), the shoreline planning area for lakes in the City is largely comprised of properties designated as low- to medium-density residential (1 to 4 dwelling units per acre). Parks, Open Space, Public Facilities/Utilities designations comprise the second largest portion of the shoreline. Small areas designated as commercial, office and multi-family comprise the remainder. The exception to this is North Lake, which is about one-half single family and one-half office park uses. The Comprehensive Plan Map does not include future land use designations for lakes in the PAA.

The City's existing Shoreline Master Program goals and policies are included as an element in the land use chapter of the City's current Comprehensive Plan. This document also establishes shoreline environment designations as Urban, Rural, and Conservancy Environments, depending on the land use and intensity of development. All freshwater lake shoreline planning areas are designated Urban. Lake Dolloff (Reach 4) has the additional designation of Rural along the northern and northeastern shorelines. North Lake (Reach 6) has the additional designation of Conservancy along the northeastern and eastern shorelines. Existing shoreline environment designations are shown on Figures 12-D through 12-H.

5.3.3 Zoning Designations

Zoning designations in the City of Federal Way and the PAA follow the land use designations established in the City's Comprehensive Plan (Figures 12-D through 12-H) and King county Comprehensive Plan. King County zoning designations apply in the PAA until those areas are incorporated through annexation at which time, the pre-annexation zoning classifications established in the city's Comprehensive Plan will apply. Star Lake, Lake Dolloff, Lake Geneva, and Five Mile Lake are all completely within unincorporated King County; these lakes are, however, included within the City's PAA. Lake Killarney is on the border between incorporated Federal Way and the PAA. North Lake and Steel Lake are completely within the City's current incorporated area. County zoning designations in the pertinent freshwater lakes' shoreline planning areas are primarily Moderate-Density Single-Family Residential (Urban Residential Zones R-4 and R-6). More than 90 percent of the Star Lake and Lake Dolloff shoreline planning areas in the PAA are zoned by King County as Urban Residential R-6. The remaining freshwater lake shoreline planning areas within the PAA are zoned by King County as primarily Urban Residential R-4 (KCC Chpt. 21A.04.080 http://www.metrokc.gov/mkcc/Code/, KC Imap viewer http://www.metrokc.gov/gis/mapportal/iMAP_main.htm#). Federal Way pre-annexation zoning classifications in the PAA are very similar to existing county zoning classifications for the area.

City zoning within the North Lake, Steel Lake, and Lake Killarney shoreline planning areas is consistent with the Comprehensive Plan shoreline environment designations. Lake Killarney and Steel Lake are both designated as Urban shorelines and North Lake as both Urban and Conservancy shoreline. Steel Lake is zoned as primarily Single-Family Residential with small areas of Multi Family Residential and Commercial zoning. Lake Killarney is zoned as roughly two-thirds Single-Family Residential with the majority of the remaining area zoned as Office. Approximately one-half of the North Lake shoreline planning area is zoned Single-Family Residential with Corporate Park (33.90 percent) and Office (6.20 percent) zoning designations over the majority of the remaining area.

Table 12. Land Use, Zoning, and Shoreline Designations

Shoreline Reach	Existing Land Use (% Cover)		Zoning (% Cover)		Existing Shoreline Designation
Steel Lake (Reach 2)	Multi-Family	5.4	Commercial	2.8	Urban
	Open Space	0.0	Multi-Family	5.9	
	Park	9.7	Single-Family	86.5	
	Right-of-Way	4.8			
	Single-Family	67.3			
	Vacant	12.7			
Star Lake (Reach 3)	Commercial	3.7	Single-Family	93.5	Urban
	Open Space	2.8			
	Park	1.9			
	Right-of-Way	6.5			
	Single-Family	80.8			
	Vacant	2.1			
Lake Dolloff (Reach 4)	Right-of-Way	8.2	Single-Family	90.7	Urban
	Single-Family	60.2			Rural
	Vacant	29.8			
Lake Geneva (Reach 5)	Open Space	2.8	Single-Family	96.5	Urban
	Park	13.2			
	Right-of-Way	3.6			
	Single-Family	58.3			
	Vacant	20.7			
North Lake (Reach 6)	Industrial	5.7	Corporate Park	33.9	Urban
	Office	15.2	Office	6.2	Conservancy
	Open Space	8.1	Single-Family	51.2	
	Park	6.3			
	Right-of-Way	3.1			
	Single-Family	34.7			
	Vacant	21.2			
Lake Killarney (Reach 7)	Office	21.6	Office	21.6	Urban
	Open Space	0.4	Multi-Family	11.6	
	Park	11.2	Single-Family	67.0	
	Right-of-Way	0.1			
	Single-Family	53.8			
	Vacant	12.1			
Five Mile Lake (Reach 8)	Park	26.0	Single-Family	88.5	Urban
	Quasi-Public	13.1			
	Religious Service	5.8			
	Right-of-Way	11.5			
	Single-Family	32.1			
	Vacant	9.1			

5.3.4 Roads and Bridges

Roads and transportation infrastructure in the freshwater lake shoreline planning areas reflect the existing land use patterns described above. The density of roads is relatively low within the shoreline planning areas at all lakes due to the residential development and open spaces that surround. In areas where roads do pass into the City's freshwater lake shoreline planning areas, the majority of roads are functionally classified as 'local streets'. According to the Federal Way Comprehensive Plan, these roads primary function is to "provide direct access to abutting land uses and serve as feeders to [road] facilities with higher functional classifications" (FWCP Chpt. 3, III-15). Traffic levels on local roads are light relative to what is seen on collector or arterial roads.

Roads and transportation infrastructure near or adjacent to waterbodies can create adverse impacts to those natural systems by blocking flow or creating impervious surfaces. Roadways represent a significant source of impervious surface in urban areas. Auto-related pollutants including petroleum products, hydrocarbons, and heavy metals accumulate on road surfaces and are carried to nearby waterbodies during storm events through sheet runoff or stormwater collection systems.

5.3.5 Wastewater and Stormwater Utilities

Lakehaven Utility District (District) provides sanitary sewer service within the City's boundaries and to unincorporated areas to the east and north of the City (including all PAA regions except a small area at the northeast most extent of the PAA area). The District's system is described in Section 4.3.5.

Of the 27 pump stations in the District system, 2 are in close proximity to the City's freshwater lake shoreline planning areas. Pump Station Number 31 is near Star Lake to the south, across Star Lake Road along 37th Avenue South. Pump Station Number 12 is near Lake Dolloff to the northeast, near the intersection of 37th Avenue South and South 304th Street.

The City of Federal Way's *Comprehensive Plan* is described in Section 4.3.5. The plan describes that residential areas in Federal Way and the surrounding PAA at that time of adoption in 2002 primarily utilized septic tanks and drainfields. Recommendations within the plan include the expansion and upgrade of existing treatment and conveyance facilities, and installation of new conveyance facilities to provide service to areas in the City and PAA using on-site septic systems.

The City of Federal Way operates a Surface Water management Utility. According to the City's Comprehensive Plan (2002), the City has completed projects to create regional detention and treatment facilities serving the City over the last decade. Localized stormwater treatment is also required for new developments. The 1994 Surface Water Facilities Plan (City of Federal Way, 1994) indicates that regional facilities have been designed with a 100-year flood storage capacity. Chapter 21 of the Federal Way Municipal Code establishes stormwater standards for new development.

5.3.6 Other Utilities

According to the City's Comprehensive Plan (2002) and the Lakehaven Utility District's (District's) Comprehensive Water System Plan (1994), the District maintains decentralized water supply production facilities that serve the majority of the City. The District operates 27 wells with the water system connected by interties to the water supply of other utility districts. The system allows the District to buy and sell water according to intra-District supply demands. Water systems attached to the District through interties include the Highline Water District, Tacoma Public Utilities, and the City of Milton's water supply system. Portions of the City's water supply is provided by these surrounding water supply systems and other neighboring water suppliers. The City's PAA is partially within the Districts water supply area and those of neighboring water suppliers. In addition, the City of Tacoma, Fruitland Water District, and several private landowners own production wells.

A variety of gas, telephone, electric, and related utilities serves the existing residential and commercial developments within the freshwater lakes' shoreline planning areas.

5.3.7 Existing and Potential Public Access Sites

The City of Federal Way has a diversity of parks, open space, and public facilities, some of which provide shoreline access. Of the seven freshwater lakes included in this shoreline plan inventory, only Star Lake and Lake Dolloff are without public access. Existing public access parks are owned and operated by the City, King County, and Washington State. The City's Parks Website (2006), King County's Parks Website (2006a), and Washington State's Park Website (2006) describes the following parks, open spaces, and public facilities in the City's freshwater lake shoreline planning area. These areas are shown on Figure 13.

Steel Lake Park

Public access is provided at various locations within the park including a Washington Department of Fish and Wildlife boat ramp located in the northeast corner of the park. This park is located on the southern shore of Steel Lake. Included in the 51.7 acre park is beach and lake access, a boat launch, and swimming and fishing areas. Other park amenities include a children's playstructure, a sand volleyball court, 5 picnic areas, restrooms, a parking area and a concessions building. The park continues across South 312th Street to the south, with additional parking (roughly 100 total stalls), 3 ballfields, and a skate park.

Star Lake and Lake Dolloff

Although there is not a park at either Star Lake or Lake Dolloff, the public has access via a public boat ramp at Dolloff and via a street end boat access at Star..

Lake Geneva Park

Lake Geneva Park, owned and operated by King County, extends to the east from the northeast shore of Lake Geneva. Included in the 18.64 acre park is beach and lake access, a fishing area, and a non-motorized boat put-in area. Other park amenities include a children's play structure, open playfields, 5 picnic areas, 1 covered picnic area, restrooms, a parking area and two ball fields. On the eastern shore of the lake, the public has access via a WDFW boat ramp.

Lake Killarney and North Lake Public Fishing Areas

Washington Department of Fish and Wildlife owns and operates public fishing areas at Lake Killarney and North Lake. Both areas include public access to the respective lakes as well as public restroom facilities. Lake Killarney Public Fishing Area, located at the north end of the lake, includes a gravel parking area as well as a boat ramp into the lake. North Lake Public Fishing Area, located at the north end of the lake, includes two paved parking stalls. A trail maintained by Weyerhaeuser runs along the western shoreline of North Lake.

Lake Killarney Park

Lake Killarney Park, owned and operated by the City, extends northwest from Lake Killarney to the corner of South 349th Street and Weyerhaeuser Way South. Included in the 12-acre park is lake access along walking trails and at picnic facilities. The City describes the park as being a 'Neighborhood / Open Space Park'. A WDFW boat ramp provides water access on the eastern shore. Fishing and boating are popular activities at Lake Killarney.

Five Mile Lake Park

Five Mile Lake Park, owned and operated by the King County, extends to the northeast from the lake's eastern shore. Included in the 31.94 acre park is beach and lake access, including swimming and fishing areas. The swimming area includes a floating swim platform and a bathhouse facility. The fishing area includes a pier. Other park amenities include a children's play structure, a sand volleyball court, 2 picnic areas, 3 picnic shelters, 2 barbeque areas with 7 barbeque pits, a lookout tower, local trails, several sports courts, 2 baseball fields, an open play field, restrooms, 2 parking area and a concessions building.

5.3.8 Historical/Cultural Resources

The existing Federal Way Comprehensive Plan provides a general goal to identify, protect, and restore those areas and facilities within the City that are of historical or archeological significance (City of Federal Way, 2002). The plan establishes a goal to ensure that historic properties and archeological sites are protected as 'important elements in the overall design of the City. Policies in the Comprehensive Plan define characteristics that enable the identification of historic and archeological sites, and direct the City to preserve and protect these sites from incompatible land uses.

There are no known archeological or historical resources within the freshwater lake shoreline planning areas. However, native American archaeological resources may exist along the shoreline of the freshwater lakes in the City and its PAA. The Washington State Department of Archeology and Historical Preservation does not indicate any areas within and adjacent to freshwater lake shoreline designation as being included in their database of listed properties (DAHP). The Historical Society of Federal Way documents the history of a series of dance halls associated with parks and resorts at several of the lakes within the City and the PAA, however none of the dance hall structures remain (Historical Society of Federal Way, 2000). The City requires review of archeological and historical resources on a parcel-by-parcel basis during development review.

6.0 RESTORATION AND OPPORTUNITY AREAS

This section summarizes key findings concerning how functions of coastal and freshwater lake shorelines have been impaired, both by land use activities and alterations occurring at an ecosystem-wide scale, and by activities within the City, its PAA, and its shoreline planning area. This section also identifies opportunities for the protection or enhancement of areas where shoreline ecological functions are intact, and opportunities for restoration of impaired shoreline functions, at both a programmatic (i.e., City-wide) and site specific level. Discussion of site-specific opportunities focus on publicly owned areas with enhancement and restoration potential as well as privately owned areas of restoration potential that could be targeted through a landowner – City partnership. Opportunities for enhanced or expanded public access to the shoreline are also discussed.

6.1 Coastal Areas / Nearshore Environment

6.1.1 Status of Shoreline Functions

Table 13 provides a summary of shoreline ecological functions for the Coastal/Nearshore Environment. Causes of impairment and the relative scale at which impairments are occurring (e.g., watershed, PAA-wide, shoreline reach scale, or multiple scales) are identified. Finally, general or programmatic restoration opportunities to address impairments are described.

Following Table 13 is a more detailed discussion of site-specific restoration opportunities.

Table 13. Summary of physical features, biological resources, and land use patterns of freshwater lake reaches in Federal Way.

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Programmatic Restoration Opportunities
Bulkheads on shoreline deflect wave action and disrupt natural coastal processes. Bulkheads disrupt natural delivery of sediment to the coastal areas, as well as increase beach scouring and wave deflection.	Watershed scale, Reach scale	Hydrologic, Sediment transport and deposition	Remove bulkheads or replace with soft-shore armoring wherever possible.
Alteration to and development on feeder bluffs reduce the potential of these areas to provide sediment delivery to coastal zones, disrupting natural coastal beach accretion.	Watershed scale	Sediment Delivery	Protect high priority feeder bluffs and preserve these areas. Restore feeder bluffs, remove bulkheads and reestablish some sediment delivery processes.
Wetlands adjacent to the Puget Sound coast are altered due to development and land use and can no longer provide essential storage, recharge, or water quality functions.	Watershed and Reach scale	Hydrologic Hyporheic Water quality	Target local coastal wetland restoration and mitigation so they provide storage, detention, and water quality functions. Restore and reconnect

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Programmatic Restoration Opportunities
			wetlands adjacent to Puget Sound coast to provide salmonid habitat.
Riparian habitat along the coast has been impaired through land development. Forest riparian vegetation exists but over time has been reduced. Large woody debris recruitment is limited.	Watershed scale and Reach scale	Riparian habitat structure	Protect and restore tributaries to the Puget Sound which provide habitat and deliver woody debris and sediment.
Man-made debris and remnant structures in the coastal areas disrupt intertidal habitats and salmonid passage. Water quality in the nearshore environment is impaired due to remaining creosote pilings and other toxic debris. Sediment transport and accretion processes disrupted.	Watershed and Reach Scale	Intertidal habitat, Water quality	Target removal of abandoned man-made structures and dilapidated docks where possible. Remove creosote pilings and debris, which harm intertidal habitats.

6.1.2 Programmatic Restoration Opportunities

There are several general protection and restoration measures that can be applied to all of the coastal/nearshore shorelines in Federal Way (see King County, 2005b). These include the following:

- Protect and maintain existing riparian vegetation and forested areas;
- Prevent encroachment on functional riparian and wetland habitat;
- Educate property owners on the importance of the nearshore zone;
- Allow LWD to remain in the shoreline to provide structure for refuge;
- Limit additional bulkheads; promote development of natural shorelines and habitats;
- Include the use of shoreline setbacks for new construction and promote shoreline vegetation buffers;
- Maintain public access to the shoreline;
- Conserve or restore stream mouths; and
- Conserve or restore connections to upland sediment sources (feeder bluffs).

A recent study, conducted by Johannessen et al. (2005), prioritized all drift cells within the WRIA 8 and 9 marine shores for restoration and conservation. The results of the study indicate that the WRIA 8 and 9 marine shorelines of the Puget Sound East reach are of moderate to high conservation and restoration priority. The bluffs of Puget Sound West were slightly less of a conservation and restoration priority, as much of the shoreline already falls within public park boundaries, where development is already prohibited.

The historic character or shoretype (feeder bluff, transport zone, or accretion shoreform) of modified shores was investigated in Johannessen et al. (2005). Reaches that are currently

modified but contained historic sediment sources were compared across the shoreline planning area. This data was prioritized based on the level of impact to the drift cell the unit falls within and the value of that particular shore unit as a sediment source. Individually mapped feeder bluff units were also compared across the entire study area and prioritized for conservation based on the variable impacts to geomorphic processes (the amount of remaining feeder bluff in the drift cell compared to historic conditions) and the value of that unit as a sediment source.

Three bulkheaded bluff segments in Puget Sound East were selected as bluffs of high restoration priority or bulkhead removal (numbers 20-22 in Johannessen et al. 2005). Three segments were also identified in Puget Sound West, each located within the bulkheaded shores between Dumas Bay Park and Dash Point State Park. Several bluffs that are still functioning feeder bluffs were identified as being of high conservation priority within the Federal Way shoreline. Only one bluff is of high conservation priority in Puget Sound East, which is located approximately 0.5 miles from the eastern limit of the study area. Several bluffs in Puget Sound West were identified for conservation. These include all mapped feeder bluffs in Dash Point State Park, and most of the feeder bluffs mapped along the north and northwestern sides of the headland just west of Dumas Bay Park.

6.1.3 Site-Specific Restoration Opportunities

The following specific restoration opportunities are listed for each coastal Puget Sound reach, in order from east to west (Johannessen et al., 2005; Anchor, 2006). The prioritization of marine shorelines of WRIA 9 (Anchor, 2006) has been included in this document as Appendix C. Discussion of site-specific opportunities focus on publicly owned areas with enhancement and restoration potential as well as privately owned areas of restoration potential that could be targeted through a landowner – City partnership. General locations are shown on Figures 14, 14a through 14 c.

Puget Sound East

- Bulkhead removal (points 44, 45 in Johannessen et al. 2005)
- Conserve feeder bluffs in the center of drift cell
- Rehabilitate riparian vegetation at residential properties along the shore

Dumas Bay

- Remove fill and bulkhead
- Remove concrete footings of relict boat ramp
- Remove boulders, concrete from boat house acting as groin
- Remove concrete rubble
- Remove bulkhead and invasive species from Poverty Bay Park
- Remove creosote logs
- Remove Japanese knotweed
- Remove approximately 20 creosote piles
- Conserve and restore tributary mouths at Dumas Bay
- Fully reconnect the marsh at west end of Dumas Bay that is currently restricted by a berm

Puget Sound West

- Conserve unarmored shoreline west of Dumas Bay
- Remove creosote dolphin washed ashore
- Remove decaying barge and creosote dolphins
- Remove creosote soldier pile bulkhead
- Remove tires buried in sediment
- Remove creosote piles
- Remove 50 creosote piles and failed creosote bulkhead
- Remove riprap downstream of bridge in Dash Point State Park and substantially enlarge creek estuary
- Restore the mouth of Dash Point Creek by removing armor (currently in planning stages by WRIA 9), add sinuosity, and add riparian vegetation

6.2 Freshwater Shoreline Lakes

6.2.1 Status of Shoreline Functions

Table 14 provides a summary of shoreline ecological functions for the freshwater lakes classified as shorelines in the City of Federal Way. Causes of impairment and the relative scale at which impairments are occurring (e.g., watershed, PAA-wide, shoreline reach scale, or multiple scales) are identified. Finally, general or programmatic restoration opportunities to address impairments are described. Following Table 14 is a more detailed discussion of site-specific restoration opportunities per each lake identified.

Table 14. Summary of Shoreline Functions and Programmatic Restoration

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Programmatic Restoration Opportunities
Stream base flows may be impaired. Summer low flows in the Hylebos Creek have declined. Potential causes include increased impervious area and increased stormwater runoff. Lakes store surface waters and support stream base flows.	Watershed scale, Reach scale	Hydrologic Hyporheic	Protect groundwater and natural surface water sources to the lakes. Restore natural flow patterns where possible.
Wetlands separated from the lakes can no longer provide essential storage, recharge, or water quality improvement functions.	Watershed, and reach scale	Hydrologic Hyporheic Water quality	Target local wetland restoration and mitigation so they provide storage, detention, and water quality functions. Restore and reconnect wetlands adjacent to lakes and Hylebos Creek.

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Programmatic Restoration Opportunities
Bulkheads and other hard shore armoring disrupt natural connections between the lake and riparian habitats.	Watershed, Reach	Hydrologic Riparian Habitats	Promote replacement of bulkheads with soft shore alternatives. Replant riparian habitats using native trees and shrubs.
Habitat is impaired along the lake shores. The lack of lakeshore vegetation and riparian structure has limited the habitat diversity, habitat quality, and reduced large woody debris.	Watershed scale, Reach scale	Instream and riparian habitat structure Water quality Biological functions	Provide/encourage native landscaping along the lakeshores, including forested riparian habitat wherever possible. Minimize future removal of trees.
Surface water runoff from impervious surfaces delivers pollutants and sediment to the lakes, which in turn adversely affects lake water quality. The potential causes of water quality impairment (i.e., contamination by fecal coliform) include leaking septic systems and animal wastes entering the stream (in the City and upstream in the watershed). Residential landscaping or other sources may be delivering increased nitrates, phosphorus and pesticides. Stormwater related pollutants (concentrated in urbanized areas including the City) may be the primary cause. Erosion and stream scouring caused by flash run-off from impervious surfaces.	Watershed, PAA-wide, and reach scale	Water quality Riparian habitat	Provide continued efforts in surface water quality improvement. Manage, detain and treat stormwater discharging to the lakes. Coordinate with King County to develop BMPs with existing property owners to reduce runoff and pollutant loading. Protect adjacent wetlands that serve to improve water quality to lakes. Target wetland restoration and mitigation in areas where they would provide water quality functions. Encourage Low Impact Development and infiltration.

6.2.2 Programmatic Restoration Opportunities

There are several general protection and restoration measures that can be applied to all of the shoreline lakes in Federal Way. These include the following:

Protection Opportunities:

- Protect and maintain existing wetlands and riparian vegetation
- Protect existing forested areas in the parks and along the shoreline
- Prevent encroachment on functional riparian and wetland habitat
- Educate property owners on the importance of the nearshore zone and general lakeside stewardship practices
- Promote development of nearshore, in-water structure such as downed trees
- Limit shoreline modifications
- Limit additional bulkheads; promote development of natural shorelines and habitats
- Include the use of shoreline setbacks for new construction and promote shoreline vegetation buffers
- Maintain public access to the lakes

Restoration Opportunities:

- Restore nearshore structures or develop buffer zones where possible
- Expand buffer zones or improve buffer quality around wetlands where possible
- Direct stormwater runoff away from the lake or into containment ponds
- Highlight locations for effective stormwater retrofitting

6.2.3 Site-Specific Restoration Opportunities

General locations of site-specific opportunities are shown on Figure 15 and described below. More detail in site-specific restoration opportunities will be provided for the freshwater lakes in the Restoration Planning element of the SMP update.

Steel Lake

The stewardship efforts of the Steel Lake Management District (limited to aquatic plant management activities) should be supported. This lake also has a higher percentage of armored shoreline and this practice should be discouraged. Existing bulkheads could be replaced with bioengineered shore protection. Although the park is large for this size lake, little nearshore vegetation remains. Sections could be restored and used as educational demonstrations for other property owners

Star Lake

Although most of the shoreline is developed, bulkheads are used minimally at Star Lake. This should be showcased and additional armoring should be discouraged. Property owners could also be further educated on the advantages of creating 15 to 20-foot wide native vegetation buffers to protect the water quality at the lake.

Lake Dolloff

Since Lake Dolloff still has good riparian vegetation, it is important to maintain and enhance current practices. Through continued education these buffer zones may continue to be kept in a functional state. The floodplain boundaries should be used to keep development away from the shoreline.

Lake Geneva

Along the eastern shoreline, special consideration should be given to creating a conservation zone or strong development regulations. The steeper shoreline lends itself to tiered development, which would greatly reduce the potential for recruitment of large woody debris. Currently, the mature trees along this area provide excellent habitat.

North Lake

Support Weyerhaeuser's continued maintenance of the large conservation area on the western shoreline. Continue to support the North Lake Steering Committee to promote lake stewardship activities.

Lake Killarney

Promote the importance of mature trees on properties, since most properties still contain multi-storied vegetation. The southern shoreline is moderately steep, however development is not yet tiered and should not be permitted.

Five Mile Lake

With bulkheads existing already along at least 50 percent of the shoreline, it is most important to limit any additional armoring of the shoreline. Property owners should also be educated about the importance of maintaining mature trees in the riparian area.

7.0 DATA GAPS

Data gaps were identified through the preparation of this report and through this characterization. These gaps include:

- Information on the hydrological budgets of the lakes including surface and subsurface inflows and outflows, precipitation, and evaporation;
- Information on sedimentation inputs to the lakes;
- Water quality information for lakes specific for toxins, nutrients and pathogens;
- Inventory of large woody debris contributions to the lakes;
- An assessment of the littoral habitat for lakes; and
- Site-specific information related to bulkheads and lakeshore vegetation, especially on the lakes within the PAA.
- General knowledge of kelp and its biology, its role in nearshore ecological processes, historical or recent studies, and distribution data.

8.0 CONCLUSIONS

The City of Federal Way shoreline planning area includes both the coastal area of Puget Sound and seven freshwater lakes within the City and its PAA. There are 16.9 miles of shoreline within the Federal Way planning area of which the Puget Sound coastal shoreline consists of 4.8 miles of shoreline, and freshwater lakes comprise 12.1 miles. Lakes included in the shoreline planning area are Steel Lake, Star Lake, Lake Dolloff, Lake Geneva, North Lake, Lake Killarney, and Five Mile Lake.

8.1 Coastal Puget Sound

Bluffs, beaches, bays, and the mouths of several freshwater streams characterize the coastal / nearshore shoreline. Feeder bluffs occur along approximately 37 percent of the coastal shoreline, with most of these occurring near Dash Point State Park. The net-shore drift direction is generally west to southwest, except at Dumas Bay where the drift cells converge to direct sands and beach substrate into the Bay from both the southwest and the northeast (Table 15).

Approximately 40 percent of the City's coastal shoreline has been modified with riprap, concrete or wooden bulkheads. Structures in the shoreline can limit the amount of sediment transported from upland areas to the beach, and are known to cause erosion and loss of some habitats such as sand and fine gravel beaches. Currents naturally move sediments across the beach and alongshore in continual cycles, but these structures interrupt the natural supply and distribution of sediments, causing a change in sediment composition within the nearshore area. However, shoreline in Dumas Bay and Dash Point State Park are in a more natural condition, and coastal processes are less altered.

The City's coastal shorelines are used by a variety of aquatic and terrestrial species including fish, salmonids, birds, mammals, and a wide variety of invertebrates. Of special interest are areas that provide habitat for federally listed species and species of local importance, including bull trout (threatened), Chinook salmon (threatened), coho salmon, as well as great blue heron nest sites. Forage fish such as surf smelt and sand lance (prey for salmonids) spawn on local beaches.

The major land uses along the Federal Way coastal / nearshore shoreline are single-family homes, parks, and public facilities. The City's most common shoreline use is single-family residential, which occupies 55 percent of the coastal shoreline. Parks and public recreational facilities occupy 18 percent of the coastal shoreline. These uses include Dash Point State Park, Dumas Bay Park, Dumas Bay Centre, and Poverty Bay Park. These areas provide opportunities for fishing, hiking and beach recreation.

The Puget Sound shoreline in Federal Way is characteristic of urbanizing shoreline elsewhere in the region. Public access to the shoreline, recreational opportunities, and water-oriented uses such as boating and fishing are provided in the City. In this regard, the goals of the SMA related to public use and enjoyment of the State's shorelines are being met in the City.

Opportunities for site-specific habitat enhancement or restoration of shoreline ecological functions have been identified based upon watershed information. In the coastal Puget Sound

areas, restoration focuses on removal of abandoned creosote pilings, debris and concrete from the shoreline. Restoration in the coastal shoreline also focuses on bulkhead replacement with soft-shore armoring and the use of native marine riparian plantings. These site-specific projects would provide small but valuable efforts toward habitat enhancement and restoration of impaired ecological functions.

Table 15, below, summarizes the detailed marine reach inventory presented in Chapter 4 of this report. Discussion of programmatic and site specific restoration opportunities for the City's marine reaches is presented in Chapter 6 of this report.

Table 15. Summary of physical features, biological resources, and land use patterns of marine shoreline reaches in Federal Way.

Shoreline Reach	Physical Features	Biological Resources	Land Use Patterns
Puget Sound East (1A)	• Sediment transport: southwestward; greatest amount of wave energy throughout study area. • 28% of shore is modified. • Typical beach profile: mixed conifer /deciduous riparian buffer atop 80- to 100-foot bluffs, base of bluff commonly armored w/ riprap, beach is narrow, sandy low-tide terrace waterward of beach face. • Landslide hazard areas: ~ 47% of reach • Shoreline slope stability: Predominantly unstable, w/ some history of recent and old landslides. • Four unnamed, short streams; all w/ steep gradients and association w/ landslide and erosion hazard zones.	• Two City inventoried Class 3 wetlands w/in shoreline planning area, near 9th Ave. SW; NWI maps intertidal WLs along entire reach (likely not state or locally regulated). • Low to moderate quality riparian habitat, due to shoreline modifications; mixed trees & grasses, LWD accumulation in areas w/out modifications. • Marine intertidal habitat: Intertidal flat and subestuary associated w/ stream at State Park; Mapped continuous and patchy eelgrass beds; Past mapping of Kelp beds, however no longer exist. • Use by a variety of aquatic and terrestrial species including fish, birds, mammals, and invertebrates. Of special interest: federally listed species and species of local importance, including bull trout (threatened), Chinook salmon (threatened), coho salmon, great blue heron nest sites. Forage fish (surf smelt & sand lance) spawn on local beaches.	• Existing land use: Predominantly (45% to 63%) single family residential, with low to moderate densities. Additional uses include Parks and Open Space areas (36 to 40%), as well as vacant areas, utility and road right of way, and multi-family uses. • Comprehensive Plan: Supports preservation of existing single-family residential neighborhood character, as well as protection of natural resources and promotion of economic development. The Comp Plan map reflects current land use (predominantly low- to moderate-density residential, with park, open space, utility, and road right of way designations making up the remainder of shoreline area. • Zoning: Reflects Comp Plan designations. • Existing public access is provided by Dash Point State Park (1c), Dumas Bay Park (1b), Dumas Bay Centre (1b), and Poverty Bay Park (1b/1a). Additional public access opportunities are limited, as the remainder of the shoreline is privately owned.
Dumas Bay (1B)	• Sediment transport: convergence of drift-cells from SW and NE. • 67.6% of shore is modified. • Typical beach profile: residential dwellings behind 3- to 5-foot high banks, frequent bulkhead backshore, 80-255 ft. wide sand with pebble beach. • Landslide hazard areas: ~ 38% of reach • Shoreline slope stability: Intermediate to unstable, w/ some history of old landslides. • Three streams, including Joe's Creek, Lakota Creek, and Dumas Bay Creek. Joe's and Lakota are more significant streams, flowing from upland areas through residential and park areas. Both 303(d) listed recently for Fecal Coliform.	• NWI/City inventoried Class 1 PEM/PSS wetland w/in shoreline planning area; Additional City inventoried Class 3 WL in NE portion of reach; NWI maps intertidal wetands along entire reach (likely not state or locally regulated). • Riparian habitat dominated by grasses, however some overhanging trees on high-bluff areas; Significant areas of shoreline modification reduce riparian habitat; LWD lacking in reach. • Marine intertidal habitat: Intertidal flats and subestuaries associated w/ streams draining into Dumas Bay; Mapped continuous and patchy eelgrass beds; Past mapping of Kelp beds, however no longer exist. • Use by a variety of aquatic and terrestrial species including fish, birds, mammals, and invertebrates. Of special interest: federally listed species and species of local importance, including bull trout (threatened), Chinook salmon (threatened), coho salmon, great blue heron nest sites. Forage fish (surf smelt & sand lance) spawn on local beaches.	
Puget Sound West (1C)	• Sediment transport: divergence between drift-cells KI-10-2 and 10-3. • 25.3% of shore is modified. • Typical beach profile: mixed conifer /deciduous riparian buffer w/ slumps and jack strawed trees overhanging intertidal area, atop 80- to 200-foot high slowly eroding bluffs, beach is a broad sand flat. • Landslide hazard areas: ~ 77% • Shoreline slope stability: Stable to unstable old landslides. • One unnamed stream (WRIA No. 0391); flows through steep ravine within Dash Point State Park.	• No City inventoried wetlands w/in shoreline planning area; NWI maps intertidal wetands along entire reach (likely not state or locally regulated). • Riparian habitat dominated by mature overhanging trees and LWD accumulation, especially in high bluff areas and along Dash Point State Park; habitat is only low quality for short length of shoreline armoring. • Marine intertidal habitat: Mapped patchy eelgrass beds; Past mapping of Kelp beds, however no longer exist. • Landslide hazard areas: ~ 47% of reach • Use by a variety of aquatic and terrestrial species including fish, birds, mammals, and invertebrates. Of special interest: federally listed species and species of local importance, including bull trout (threatened), Chinook salmon (threatened), coho salmon, great blue heron nest sites. Forage fish (surf smelt & sand lance) spawn on local beaches.	

8.2 Freshwater Lakes

The freshwater lakes in the City are located on a broad plateau in the eastern half of the City and in the PAA. The plateau developed from glacial recessional deposits and tills. As the glaciers melted, lakes formed in the scour areas. Lakes in the City drain to five main drainage basins including 1) the Puget Sound, 2) the Lower Green River, 3) Mill Creek, 4) the White River, 5) and Hylebos Creek/Waterway. Lake shorelines have been modified with bulkheads and other bank protection, but also have significant areas of natural shoreline conditions. On Steel Lake, Star Lake and Five Mile Lake, approximately 20 to 50 percent of the shoreline has been modified with bulkheads. Shoreline modifications are less apparent on the remaining lakes in the City (Table 16).

The City's freshwater lake shorelines are used by a variety of aquatic and terrestrial species including fish, birds, and mammals. Many of the lakes are stocked with trout, bass or other game fish. Anadromous fish (including coho) are not likely present in the freshwater lakes due to blockages to fish passage. Salmonids within the lakes are limited to stocked cutthroat trout. Bald eagle and loon also use the lakes with the shoreline planning area.

Land uses along the City's freshwater lakes are primarily single-family residential and public parks. Single-family residential use occupies between 55 and 80 percent of the shoreline on most lakes, with the exception of North Lake (35 percent) and Five Mile Lake (32 percent).

Parks, boat ramps, and public facilities occupy 9 to 39 percent of the lake shorelines. Public access to the lakes occurs via parks including Steel Lake Park, Lake Geneva Park, Lake Killarney and Five Mile Lake Park, as well as several boat ramps owned by Washington Department of Fish and Wildlife.

Development on a watershed scale has affected the shoreline by increasing impervious area in uplands, resulting in increased peak flow velocities and volumes, impaired water quality, and erosion in streams. On the lake shorelines, alterations have affected water quality, in lake habitat, and downstream habitat for salmonids.

In the freshwater lakes, restoration opportunities include enhancement of lakeshore riparian areas with native vegetation, removal or replacement of failing bulkheads, and protection of natural vegetation when present. Programmatic restoration opportunities include coordination with the City's surface water management program, public education and outreach to provide technical guidance for shoreline homeowners, and the possibility for community-based restoration on private property. Opportunities for enhancing public awareness and education could include installation of informational kiosks at public parks and waterfront use areas. The City could also coordinate with King County, the Water Resource Inventory Area (WRIA) 9 forum, and other regional or Puget Sound-wide planning efforts to implement identified restoration policies and actions.

Table 16, below, summarizes the detailed freshwater lakes inventory presented in Chapter 4 of this report. Discussion of programmatic and site specific restoration opportunities for the City's lake reaches is presented in Chapter 6 of this report.

Table 16. Summary of physical features, biological resources, and land use patterns of freshwater lake reaches in Federal Way.

Shoreline Reach	Physical Features	Biological Resources	Land Use Patterns
Steel Lake (Reach 2)	• Located in Lower Puget Sound basin. • Under-laying soils: low-permeability till. • In-flow: surface water conveyed via 14 stormwater outflows. Outflow: to Cat. 1 wetland along Western shoreline, eventually outflow becomes Redondo Crk. • Lake Management District: City established 3 yrs ago, successful in reduction of aquatic weeds. • Low quality riparian habitat due to residential development and extensive shoreline armoring.	• NWI identifies wetlands associated with and adjacent to lake. City inventory identifies a large, Category 1 WL extending from western edge of lake; several other small, Category III WLs identified. • Lake supports: stocked trout and bass. Downstream of lake, basin supports coho and fall chum salmon. • Mesotrophjc lake with very good water quality; invasive exotic species are significant concern.	• Existing land use: Predominantly (58% to 80%) single family residential, with low to moderate densities. Additional uses include vacant areas (2 %to 30%), Parks and Open Space areas (5% to 16%, except at Lake Dolloff), as well as utility and road right of way and limited multi-family (Steel Lake only) uses. • Comprehensive Plan: Supports preservation of existing single-family residential neighborhood character, as well as protection of natural resources and promotion of economic development. The Comp Plan map reflects current land use (predominantly low- to moderate-density residential, with park, open space, utility, and road right of way designations making up the remainder of shoreline area. • Zoning: Reflect City and County Comp Plan designations. • Existing public access is provided by: Steel Lake Park (WDFW boat ramp, swimming area, fishing areas, play structures and courts, picnic facilities), Lake Geneva Park (King County operated, boat ramp, fishing areas, play structures and courts, picnic facilities), boat ramps at both Star Lake and Lake Dolloff.
Star Lake (Reach 3)	• Located in Lower Green River basin, in PAA. • Under-laying soils: till & recessional outwash deposits, is likely a kettle lake. • In-flow: small streams and groundwater. Outflow: via a pipe and culvert to Bingham Crk. and Green River. • Mapped as a Critical Aquifer Recharge Area. • Low quality riparian habitat due to residential development and extensive shoreline armoring.	• NWI and City identify entire lake area as a permenant lacustrine wetland (City, Category I). • Lake supports: stocked trout, bass, and other fish. Downstream of lake, Lower Green River basin supports fall Chinook, fall chum, coho, documented presence of sockeye, pink, bull trout, and winter steelhead. • Ogliotrophic lake w/ very good water quality, however low flushing rate makes lake vulnerable to pollutants; Category 2 303(d) listing for fecal coliform.	
Lake Dolloff (Reach 4)	• Lakes are located in Mill Creek basin, in PAA. • Under-laying soils: till and recessional outwash deposits. • In-flow: small streams and groundwater. Outflow: via shoreline wetlands to a small tributary of Mill Creek (Lake Dolloff) and Mill Creek (Lake Geneva). • Lk. Dolloff: mapped as a Critical Aquifer Recharge Area. • Although the majority of buildable parcels are developed, residences are further set back from	• NWI and City identify entire lake area as a permenant lacustrine wetland (City, Category I). NWI and City also identify several small palustrine WLs in the planning area, two of which are associated w/ the lake. • Lake supports: stocked trout, bass, and other fish. Downstream of lake, Mill Creek basin supports Chinook, chum, coho, and documented presence of sockeye, cutthroat, and winter steelhead. • Eutrophic lake w/ fair water quality, low flushing rate makes lake vulnerable to pollutants; Category 2 303(d) listing for fecal coliform and phosphorus.	

Table 16 continued

Shoreline Reach	Physical Features	Biological Resources	Land Use Patterns
Lake Geneva (Reach 5)	shoreline and the majority do not have shoreline armoring.	• NWI and City identify entire lake area as a permenant lacustrine wetland (City, Category I). • Lake supports: stocked trout, bass, and other fish. Adult common loon documented near lake. Downstream of lake, Mill Creek basin supports Chinook, chum, coho, and documented presence of sockeye, cutthroat, and winter steelhead. • Mesotrophic lake w/ good water quality, low flushing rate makes lake vulnerable to pollutants; meets all State water quality standards.	
North Lake (Reach 6)	• Lakes located in Hylebos Crk. basin, in south-central part of the City (Lk. Killarney partially in PAA). • Under-laying soils: till deposits. • In-flow: small tributary (North Lk.), associated wetlands, runoff, and limited groundwater. Outflow: via shoreline wetland to a small tributary, then to a pond, and eventually the west fork of Hylebos Crk (North Lk.) and via a convert culvert and trib. to east fork of Hylebos Crk. (Killarney Lk.) • Shoreline armoring is minimal, however especially so on the western (North Lk.) and northern (Killarney Lk.) shorelines.	• NWI and City identify entire lake area as a permenant lacustrine wetland (City, Category I). NWI and City also identify several small palustrine WLs in the planning area. • Lake supports: stocked trout, bass, and other fish. Eagle nest documented ½ mile from North Lake. Downstream of lake, Hylebos Creek basin supports chum, coho, and cutthroat. • Mesotrophic lake w/ good water quality, moderate flushing rate makes lake moderately vulnerable to pollutants; meets all State water quality standards.	• Existing land use: Predominantly (35% to 54%) single family residential, with low to moderate densities. Additional uses include office/industrial (~22%), vacant areas (12% to 21%), parks and open space areas (12% to 14%), as well as utility and road right of way. • Comprehensive Plan: Supports preservation of existing single-family residential neighborhood character, as well as protection of natural resources and promotion of economic development. The Comp Plan map reflects current land use (predominantly low- to moderate-density residential, with office/industrial, park, open space, utility, and road right of way designations making up the remainder of shoreline area. • Zoning: Reflect City and County Comp Plan designations. • Existing public access is provided by: Lake Killarney Park (12 acres, walking trails, picnic facilities), a trail owned and maintained by Weyerhaeuser along North Lake, and boat ramps at both North Lake and Lake Killarney.
Killarney Lake (Reach 7)		• NWI and City identify entire lake area as a permenant lacustrine wetland (City, Category I). NWI and City also identify several small palustrine WLs in the planning area. • Lake supports: stocked trout, bass, and other fish. Eagle nest documented ½ mile from North Lake. Downstream of lake, Hylebos Creek basin supports chum, coho, and cutthroat. • Eutrophic lake w/ good water quality, low flushing rate makes lake vulnerable to pollutants; Category 2 303(d) listing for fecal coliform and phosphorus.	

Table 16 continued

Shoreline Reach	Physical Features	Biological Resources	Land Use Patterns
Five Mile Lake (Reach 8)	• Located in White River basin, in PAA. • Under-laying soils: till & recessional outwash deposits, is likely a kettle lake. • In-flow: wetlands to north, springs, runoff, & groundwater. Outflow: drains to Trout Lk., which drains to White River. • Mapped as a Critical Aquifer Recharge Area. • Shoreline armoring is common on developed residential parcels, making approximately 25% of the shoreline.	• NWI and City identify entire lake area as a permenant lacustrine wetland (City, Category I). NWI and City also identify several small palustrine WLs in the planning area, one of which is associated with the lake. • Lake supports: stocked trout and bass. Adult common loon documented near lake. The White River basin supports Chinook, chum, coho, and pink salmon, as well as documented presence of sockeye, cutthroat, and winter steelhead. • Mesotrophic lake w/ good water quality; Category 2 303(d) listing for fecal coliform.	• Existing land use: Predominantly (32%) single family residential, with low to moderate densities. Additional uses include parks and open space areas (39%), vacant areas (9%), as well as utility and road right of way. • Comprehensive Plan: Supports preservation of existing single-family residential neighborhood character, as well as protection of natural resources and promotion of economic development. The Comp Plan map reflects current land use (predominantly low- to moderate-density residential and park area, with open space, utility, and road right of way designations making up the remainder of shoreline area. • Zoning: Reflect City and County Comp Plan designations. • Existing public access is provided by Five Mile Lake Park (31.94 acre King County park, swimming area, fishing areas, play structures and courts, picnic facilities, walking trails).

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APPENDIX A – MAP FOLIO

APPENDIX B – MARINE SHORELINE INVENTORY REPORT WRIA 9

APPENDIX C – PRIORITIZATION OF MARINE SHORELINES OF WRIA 9 FOR JUVENILE SALMONID HABITAT PROTECTION AND RESTORATION